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COVER

Lowland Gully Shrub Forest (Map Unit 37 — see p.143) at Saltwater Creek, near Eden.

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Native vegetation of the South East Forests region, Eden, New South Wales

David A. Keith and Michael Bedward

Abstract

Keith, David A. and Bedward, Michael, (NSW National Parks and Wildlife Service, PO Box 1967, Hurstville NSW Australia 2220) 1999. Native vegetation of the South East Forests region, Eden New South Wales. Cunninghamia *6(1): 001–218.* Terrestrial, freshwater and estuarine native vegetation of the Eden region was classified into 79 floristic assemblages and mapped at 1: 100 000 scale. Assemblages were derived from multivariate analysis of 1604 quantitative vegetation samples. Mapping was carried out using a hybrid decision tree-expert system approach based on quantitative relationships between floristic assemblages and spatial variables (land cover pattern, substrate, climatic variables and terrain variables) and qualitative expert knowledge derived from field experience. The use of vegetation-environment relationships and sampling of remnants allowed prediction of vegetation patterns prior to European clearing. The map was validated using three procedures: qualitative checking by experts; reliability mapping using sampling intensity; and accuracy quantification using independent sample data. The map units were described using comprehensive profiles of diagnostic species, structural features, habitat characteristics and sample distributions.

The 79 floristic assemblages include rainforests, mesic eucalypt forests, dry grassy eucalypt forests of the coastal rainshadow valleys, hinterland and tableland, dry shrubby eucalypt forests, grasslands, heathlands, scrubs and wetlands. Variation in climate and geological substrate influence vegetation patterns at regional scales, while variation in topography, local soil moisture and nutrient status and disturbance regimes influence vegetation patterns at local scales. Sixty-eight per cent of the region retained a cover of native vegetation in 1994. Processes threatening various portions of the remainder include further habitat loss from clearing, high-frequency disturbances and certain other disturbance regimes, overgrazing, habitat degradation due to nutrification, dumping and vandalism, and feral animal activity. Past depletion of habitat has been highly biased. Some grassy assemblages on fertile flat terrain are depleted by more than 90%, while some forests with shrubby understories in steep infertile terrain retain close to their original extent. The former assemblages are distributed principally as remnants on privately owned land, while the latter occur in remote areas of public land. Representation in conservation reserves is also biased against grassy assemblages in fertile flat terrain, as well as some other assemblages with restricted distributions. Opportunities for conservation of these assemblages are now very limited and rely on integrated planning, reservation and cooperative management with emphasis on private land.

For Tommy Keith (1918–1999). Best friend.

Introduction

In far south-eastern New South Wales coastal wilderness and rugged forested mountains are juxtaposed with undulating pastoral country in coastal valleys and subalpine plains. The region falls centrally within Australia's unique temperate eucalypt forest biome (Beadle 1981, Ovington 1983).

Ferdinand von Mueller, director of the National Herbarium of Victoria, was one of the earliest botanical explorers of the South East Forests in 1860. Mueller's ventures to Twofold Bay and the upper Genoa River were preceded by earlier expeditions to the Monaro Tableland by Cunningham and Lhotsky (Benson 1994, Andrews 1998). Knowledge of the regional flora developed opportunistically over a century with numerous collecting trips by botanists based in Sydney and Melbourne and, more recently, Canberra. With the development of nature conservation as a land use, a number of vegetation surveys were carried out to provide resource inventories for reserve management (Breckwoldt 1979, Gilmour 1983, Outhred 1986, Lane et al. 1998) and management of National Estate values within production forest (Fanning & Rice 1989, Fanning & Mills 1989, 1990, 1991, Fanning & Fatchen 1990, Binns & Kavanagh 1990a, b, Fanning & Clark 1991). Hitherto neglected remnant vegetation within fragmented, largely freehold agricultural landscapes of the Bega valley and associated areas was surveyed by Keith (1995) and Miles & Stone (unpubl.), while targeted surveys addressed specialised habitats including rainforest (Floyd 1982), coastal sand dunes (Clarke 1989) and saltmarsh (Clarke unpubl.).

Vegetation maps derived from aerial photograph interpretation and field reconnaissance were produced for some of the areas addressed by local surveys (e.g. Breckwoldt 1979, Gilmour 1983). Mapping of forest types (Baur 1989) was also carried out in selected areas of production forest (State Forests of NSW, unpublished maps). Vegetation surveys and small-scale vegetation maps are available for East Gippsland to the south (Forbes et al. 1982, Parkes et al. 1984, Woodgate et al. 1994), areas further north on the NSW south coast (Austin & Sheaffe 1976, Austin 1978, CSIRO 1996) and the Monaro Tableland to the west (Costin 1954).

Formation of a regional overview of the biota became an important goal with the need for environmental impact assessment of woodchipping operations (Harris-Daishowa 1986, Forestry Commission of NSW 1988) and increasing emphasis on the representativeness of regional reserve systems (Austin & Margules 1986). This began with compilation of a preliminary species list for the region (Binns 1987) and a quantitative synthesis of regional vegetation patterns (Keith & Sanders 1990). In the absence of detailed vegetation mapping across the region, surrogate maps based on modelled forest types (Skidmore 1989, Forestry Commission of NSW 1988), land systems (Keith & Sanders 1990) and environmental domains (Richards et al. 1990) were developed to provide a basis for environmental impact assessment and regional land use decisions.

A formal framework for resolving potential conflicts between competing land uses was adopted through the endorsement of Australia's National Forest Policy Statement (Commonwealth of Australia 1992). The policy provides for Regional Forest

Agreements (RFAs) between Commonwealth and State governments that will address planning and management for both a comprehensive, adequate and representative system of conservation reserves and ecologically sustainable use of forest resources (Anon. 1998). The agreements are to be negotiated using the outcomes of comprehensive regional assessments of environmental, heritage, economic and social values of the forests. A detailed regional map representing the distributions of plant and animal habitats is an essential requisite for the assessment of environmental and heritage values. Guidelines for the assessment suggest that map units, termed 'forest ecosystems' should preferably 'be discriminated at a resolution requiring a map-standard scale of 1:100 000... [and] defined in terms of floristic composition in combination with substrate and position within the landscape' (JANIS 1996).

The purpose of this study was to develop a regional land classification and map that effectively represents species distributions. Consistent with JANIS (1996), we adopted an approach based on floristic composition and its relationship with environmental variables. Although initially intended to provide the central component of an information base on biodiversity for the Eden Comprehensive Regional Assessment, classification and mapping were carried out mindful of previous work and broader needs in environmental planning, assessment and management beyond the Eden Regional Forest Agreement. The work presented here is the fourth revision (version 4.0) of a vegetation survey and map that has previously been available in published and unpublished forms (Keith & Sanders 1990, Keith et al. 1995, Keith & Bedward 1998). Revisions to the map since version 3.0 (Keith & Bedward 1998), which was used in the Eden Comprehensive Regional Assessment, relate primarily to areas of privately owned land and some rainforest and scrub assemblages.

Study Area

The study area coincides with the Eden Native Forest Management Area (State Forests of NSW 1994) in the south-eastern corner of New South Wales between Bermagui and Numeralla in the north and Cape Howe and Craigie in the south (Fig. 1). The area comprises 800 000 ha between latitudes 36°22' and 37°30'S and longitudes 149°00' and 150°05'E and is bounded by the Tasman Sea to the east, the Victorian border to the south, the Monaro Tableland to the west and an arbitrary line following watercourses, roads and landforms in the north. The Bega and Towamba Rivers and their tributaries respectively drain most of the region to the east, while the Genoa and Wallagaraugh Rivers run to the south, the Bombala and McLaughlin Rivers run to the south-west and the Numeralla and Kybean Rivers run north-west into the Murray River basin.

Landscape

Keith and Sanders (1990) described broad geomorphological and vegetation patterns in the region using land systems. A narrow coastal plain dominated by sand and gravel deposits of Tertiary and Holocene age supports heath, scrub and dry forest vegetation punctuated by coastal lagoons, estuaries and swamps. A low and broken coastal range rises to about 300 m elevation, although this height is well exceeded by individual mountains including Mumbulla Mountain (775 m), Burragate Peak (879 m),

Fig. 1. South East Forests study area based on the Eden Forest Management Area.

Mt Imlay (888 m) and Mt Nadgee (542 m). The coastal range is comprised mainly of Ordovician and Devonian siltstones and sandstones subject to varying degrees of metamorphism. Devonian granitoid intrusions outcrop at Mumbulla Mountain (tonalite) in the north and around Mt Nadgee (adamellite) in the south, while an alkali intrusion of monzonite and related rock types outcrops on Burragate Peak (Beams & Hough 1984). Localised outcrops of Devonian rhyolite and basalt occur around Nethercote, west of Pambula. The coastal range is dominated by dry shrubby eucalypt forests with mesic eucalypt forests and numerous small patches of rainforest in sheltered gullies.

Further west, the coastal range gives way to an undulating hinterland dominated by the Bega Batholith, a complex of Devonian acid volcanics including mainly adamellite and granadiorite with smaller outcrops of granite, quartz diorite, leucogranite, tonalite and gabbro (Beams & Hough 1984). Small outcrops of Ordovician metamorphosed mudstones occur throughout. The rainshadow valleys of the Bega and Towamba Rivers and Narira Creek are a feature of the hinterland. Dry grassy eucalypt forests dominate these valleys, while forests of the remaining hinterland (e.g. in the Wallagaraugh catchment) have a greater but variable shrub component (Keith & Sanders 1990).

The western parts of the rainshadow valleys are bounded by a steep granitoid escarpment that exceeds 900 m elevation at its highest point west of Bemboka. The dry lower slopes support grassy eucalypt forest, while sheltered gullies and elevated slopes receiving orographic moisture support mesic eucalypt forest and small patches of rainforest. The escarpment rises to a mountain range, generally 700–1000 m elevation, on the edge of the tableland. This range joins the Great Dividing Range east of Nimmitabel in the north and exceeds 1200 m elevation still further north at Kydra. The tableland range is dominated by granitoid geology with localised outcrops of Ordovician metamorphosed mudstones (e.g. on Wog Wog Mountain) and Tertiary basalt at Mt Darragh, Bull Mountain and Brown Mountain. Mesic eucalypt forests are the principal vegetation cover, with dry shrubby eucalypt forests occurring on more exposed slopes and ridgetops. The tableland range dissipates in the south where several isolated mountains and plateaux punctuate the terrain. These include Nalbaugh Plateau-Wog Wog Mountain, Letts Mountain, Mt Poole, Mt Waalimma, Mt Tennyson and Nungatta and Yambulla Mountains. The latter peaks form part of a dissected Devonian sandstone plateau dominated by dry shrubby eucalypt forest.

North of the Bega valley, the tableland range adjoins an extensive area of highly dissected terrain derived from Devonian metamorphosed siltstones and sandstones. This landscape is dominated by dry shrubby eucalypt forest with mesic eucalypt forest and small patches of rainforest confined to the most sheltered gorges, and heath atop the most exposed high-elevation ridges.

In the west, the tableland range declines and adjoins an extensive elevated plain, the Monaro Tableland. An extensive belt of Tertiary basalt extends along the western boundary of the study area north from Bombala. Metamorphosed siltstones, mainly of Ordovician age but some of Silurian and Devonian age, cover much of the remaining area, with some areas of Devonian granitoid rocks. Volcanic substrates support grassy eucalypt woodlands with grassland on large low-lying areas of basalt, while metamorphosed sediments support eucalypt woodlands with a mixed grass and shrub understorey. Exposed hills close to the tableland range support localised patches of heath, while bogs form on poorly drained flats.

Climate

Mean annual precipitation varies from 800–900 m on the coastal strip and generally increases orographically inland to the summits of the coastal ranges. Precipitation exceeds 1000 mm on the tableland range and is likely to exceed 1300 mm on mountain

summits such as Mt Imlay and Wog Wog Mountain. Rainshadow effects prevail in the Bega and Towamba valleys where mean annual precipitation falls below 700 mm. The Monaro Tableland is also in a rainshadow zone where the driest parts of the region near Numeralla and Bombala receive less than 600 mm annual precipitation. Preciptation is weakly seasonal in the region with late summer months likely to be wetter than late winter months.

On the coast mean daily maximum temperatures reach 25°C in February on the coast at Merimbula, while mean daily minima are 4°C in July (Commonwealth of Australia 1988). Temperature ranges increase further inland, with equivalent means for Bega being 27° and 1°C, respectively, and frost occurs on average 30 days per year. The tablelands are generally cooler all year round, Nimmitabel having a daily maximum temperature of 23°C in February and a mean daily minimum of -2°C and nearly 100 frost days (Commonwealth of Australia 1988).

Land use and management

Numerous archaeological sites within the region suggest aboriginal occupation in the region over some tens of thousands of years (e.g. Byrne 1983). Aboriginal people interacted with their environment through hunting, gathering and burning, although the extent and ways in which they influenced fire regimes are subject to speculation and debate (Benson & Redpath 1997).

European settlement began in the region in the late 1820s as squatters occupied land for grazing in the Bega and Towamba valleys (Codrington 1979, Byrne 1983, Andrews 1998) and on the Monaro Tableland (Benson 1994, Andrews 1998). By the time of Lambie's census in 1839, a population of more than 100 pastoralists and their workers and families had become established both on the coast and on the tableland (Andrews 1998). The environmental impact of pastoralism was initially slow, although native forest was cleared in localised patches within large grazing runs, and localised erosion and introduced species were recorded as early as 1830 (Lunney & Leary 1988). Agricultural land uses intensified after 1860 with conversion to freehold title and growth of the dairy industry in coastal valleys. By the first decade of the twentieth century most of the native vegetation in the Bega valley had been cleared. Clearing of the small remaining patches of native vegetation in the coastal valleys and on the tableland continued at a slow rate to the present day (Lunney & Leary 1988, Keith 1995), with a total of 32 per cent (c. 260 000 ha) of the region being cleared by 1994 (analysis of Landsat TM image).

Pastoral activities vary across the region. Intensive dairying is limited to the more productive lower parts of the Bega valley, beef cattle grazing predominates in other freehold parts of the Bega and Towamba valleys, as well as on small crown and State Forest leases scattered across the hinterland and tableland, while sheep grazing is the dominant pastoral activity on the Monaro Tableland.

In contrast to the coastal valleys and the tableland, the surrounding 'hill country' has retained a greater extent of its native vegetation cover and remains largely in public ownership. There are about 400 000 ha of naturally vegetated public land, accounting for about half of the region. Hardwood (eucalypt) forestry is a major industry in this

part of region, although sawn timber production commenced initially in the Bega valley in tandem with land clearance for agriculture (Lunney & Leary 1988). Sleeper cutting accounted for a large part of timber production from 1900 until after World War II when demand for building materials increased and made sawlog extraction more economically viable (Lunney & Leary 1988).

Selective logging continued in the most accessible parts of the region until the development of a pulpwood industry in 1969. The new industry resulted in a significant change in forest management with the introduction of integrated logging (SFNSW 1994). Under this system a high proportion of standing biomass is removed for both sawlogs and pulpwood in alternate coupes (10–200 ha patches) across the production forest landscape on a rotation of 50–80 years. Thinning operations are carried out within the regrowth forest at intervals of two to four decades.

Development of a softwood sawlog industry based on plantations of *Pinus radiata* paralleled the development of the pulpwood industry. Some 35 000 ha of plantations were established over marginal grazing lands and native forest during the 1970s and 1980s, largely in the Bombala and Pericoe areas in the west and south, respectively.

Mineral extraction is a minor land use within the region. Goldfields at Yambulla, Pambula and Wolumla were mined last century and the first two of these are now recognised as cultural heritage sites. A small industry extracting pyrophyllite from rhyolite outcrops west of Pambula has operated in recent decades.

Nature conservation was established as a formal land use within the region with the dedication of Nadgee Nature Reserve in the far south east of the region in 1962. Additions to the reserve system in the late 1960s and 1970s focussed on mountainous wilderness areas. Further additions in 1990 and 1996 and the Eden Regional Forest Agreement (1998) reflected a change in emphasis toward balanced representation of different habitats in the region (Margules & Stein 1989, Bedward et al. 1992a). Conservation within reserves entails management of fire regimes, rare and threatened species, pest species and recreational visitors. Reserves are supplemented by increasing off-reserve conservation through management of production forests, community programs and voluntary agreements with private landholders, and planning regulations administered by state agencies and local government.

Tourism has grown rapidly within the last two decades and is focussed primarily on coastal locations, heritage sites and bushland. The development of tourism is reflected in the expansion of coastal townships, particularly Merimbula and Tathra and the intensified use of the coast for recreation.

Disturbance regimes

Eden's climate supports occasional high intensity forest fires, particularly in wetter parts of the region, while drier parts of the region may experience more frequent fires of lower intensity (Keith & Sanders 1990). Dendrochronological studies of fire scars (Banks 1990) and charcoal deposition patterns in peat profiles (Polach & Singh 1980) suggest possible changes in the fire regime with patterns of human occupation and land use. Some of these changes involve a general increase in fire frequency

corresponding with European settlement (Banks 1990) and are consistent with inferences drawn elsewhere in eastern Australia (Benson & Redpath 1997). At two study sites in the upper Tantawangalo catchment, fire frequency increased in several episodes between 1830 and the early part of this century, then decreased after 1970. Overall average return times were 8 and 14 years, respectively, in dry and wet eucalypt forest sites (Banks 1990). Many of these fires are likely to have been low intensity events associated with native pasture management and timber-getting. Major fires were recorded within the region during 1988, 1983, 1980, 1972, 1968, 1964, 1954, 1952, 1939 and 1926 (SFNSW 1994). In these years, the estimated areas burnt varied between 10 000 and 80 000 ha, up to 10 per cent of the region (SFNSW 1994). Although such fires recur somewhere in the region every 2–13 years, the average return time of major wildfires is likely to be much longer than 20 years because successive fires did not always overlap, even allowing for small but intense events recorded in local parts of the region in other years (Lunney & Leary 1988, Banks 1990).

In recent years, intensive management systems in wood production forests include logging, regeneration fires and hazard reduction fires (SFNSW 1994). These disturbances are superimposed upon unplanned components of the fire regime and interact in potentially complex ways (Bradstock et al. 1995). Current management regimes in production forest includes low-intensity hazard reduction burning on a 4–7 year rotation and up to 3 years prior to logging. Logging and high-intensity regeneration burns are planned to be implemented every 50–80 years. All fires are excluded for c. 15 years after logging. Several thinning operations may be implemented at 20–40 year intervals in between intensive logging events. Integrated logging is also carried out within privately owned forests, though generally with fewer management controls.

Methods

Classification and mapping approach

Map units are widely recognised in conservation biology as potential 'surrogates' or 'coarse filters' for biodiversity (Austin & Margules 1986, Noss 1987). The use of floristic assemblages as biodiversity surrogates (JANIS 1996) is supported *a priori* by the fact that vascular flora accounts for a significant portion of the total biodiversity of a site and that plant species individually or collectively provide essential habitat resources for many other organisms. However, a range of empirical approaches suggest that the extent to which alternative map bases correctly predict species distributions remains uncertain (e.g. Burgman 1988, Bedward et al. 1992b, Pressey & Bedward 1991, Ferrier & Watson 1997, Oliver et al. 1998, Panzer & Swartz 1998). Some of these studies suggest that the predictive capability of maps may be quite poor in certain areas or for certain biotic groups (Ferrier & Watson 1997, Oliver et al. 1998). Nevertheless, there is some evidence that floristic assemblages are either better predictors of species distributions (e.g. Pressey & Bedward 1991, Ferrier & Watson 1997) or no worse than alternative classifications and maps (e.g. Burgman 1988, Ferrier & Watson 1997), even though the range of different map bases examined is limited.

Furthermore, some substantial methodological sampling issues remain to be overcome in empirical studies of map surrogacy (e.g. Ferrier & Watson 1997).

In this study we have developed a classification based on floristic composition using an approach illustrated in Fig. 2. We used quantitative analyses of field samples to interpret and classify compositional patterns and then carried out mapping as an independent step using environmental relationships and remote data (e.g. Keith 1994, Brooker & Margules 1996). This contrasts with traditional mapping approaches, which place primary emphasis on remote sensing for both the definition and mapping of vegetation classes (e.g. Keith & Benson 1988, Baur 1989, Sun et al. 1996). Quantitative field samples offer greater accuracy and precision in the measurement of floristic composition than remote data combined with qualitative field reconnaissance especially, though not only, for understorey species which account for more than 90 per cent of floristic diversity in this region. Quantitative samples also lend themselves to explicit multivariate analysis, which may detect patterns that escape recognition by traditional intuitive methods. Mapping was carried out using explicit decision rules to interpolate the distributions of floristic classes from point samples using relationships between the classes and environmental and remote structural variables that were available as spatial data layers (Fig. 2). The separation of mapping as an independent step based on explicit data-dependent decision rules maximises mapping consistency and reduces the role of non-repeatable intuitive classification and mapping decisions.

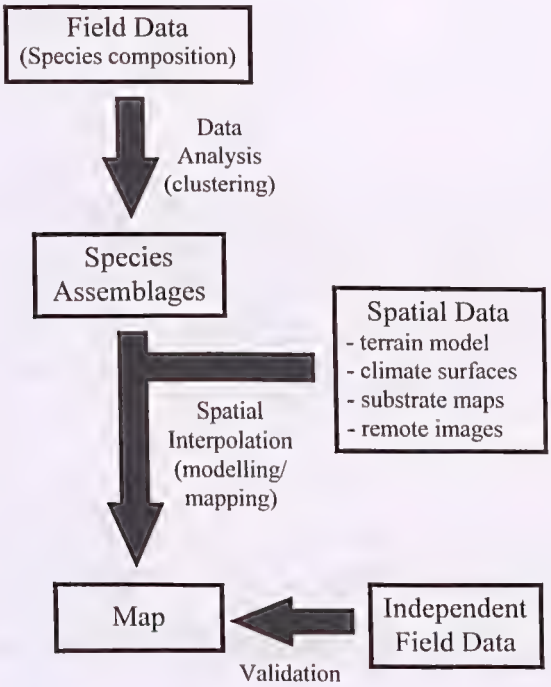

Fig. 2. Approach to vegetation classification and mapping based on field samples.

Vegetation data

Sample stratification

Sampling was stratified by parent material, elevation and terrain. The samples were gathered over a period from 1987 to 1997. Sample stratification was refined iteratively over this period with field sampling targeted to fill gaps. The progressive evaluation of sampling gaps also took into consideration suitable data available from other sources (see below). The final sample stratification was based on eight classes of parent material, seven classes of altitude, two classes of slope and three classes of aspect on steep slopes (Table 1). The distributions of sampling strata were mapped by intersection of relevant spatial data layers in a geographic information system (Eastman 1993). This was used in fieldwork planning and, in conjunction with a recent digital Landsat coverage, allowed the naturally vegetated extent of each stratum to be calculated. As expected, the distribution of strata in the study area was highly skewed with 100 of 224 possible strata not represented within the study area and only 17 of the remaining 124 strata accounting for more than 50% of the naturally vegetated area.

One hundred and two of the 124 sampling strata with extant vegetation were sampled (Table 1). The remaining unsampled strata represented environments covering less than 0.02% of native vegetation in the region, suggesting that sampling had a qualitative coverage of regional environmental variation. The most widespread strata were covered by larger numbers of samples (Table 1, Fig. 3).

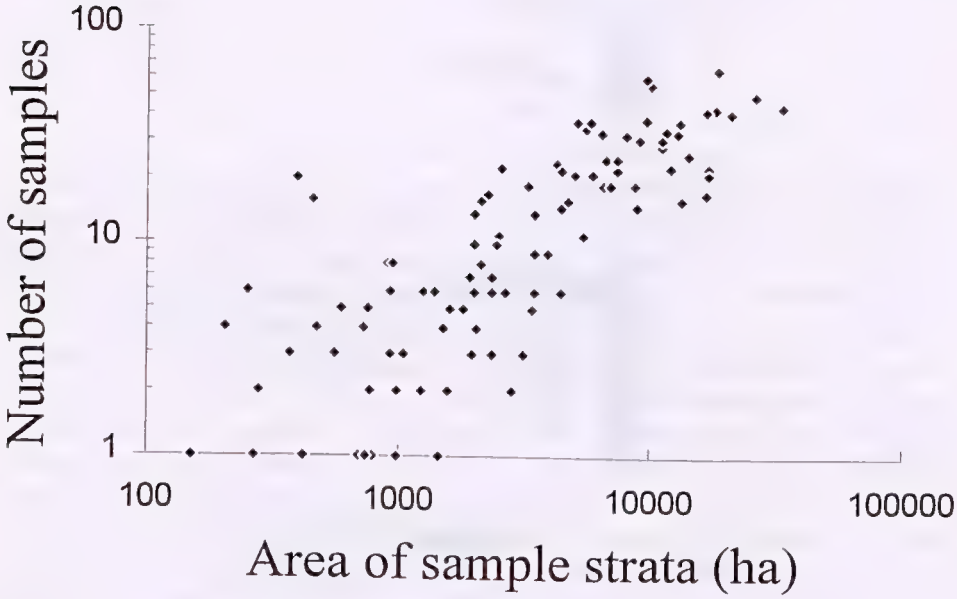

Fig. 3. Numbers of samples in sampling strata of varying extent (excluding cleared land).

Table 1. Sample stratification by classes of substrate, terrain and elevation. Data are number of samples and area (extant) under native vegetation (ha). Terrain classes: flat, slope ≤ 5°; north, slope > 5° and aspect < 30° or > 300°; intermediate, slope > 5° and aspect 30–120° or 210–300°; south, slope > 5° and aspect 120–210°. Elevation in metres above sea level.

Substrate/terrain	Elevation	0–150	151–300	301–450	451–600	601–750	751–900	> 900	Total
Riverine alluvium									
flat	#samples	14	-	2	-	-	-	1	17
	extant area	2002	0	279	0	0	0	87	2616
north	#samples	1	-	-	-	-	-	-	1
	extant area	776	0	0	0	0	0	0	855
intermediate	#samples	5	-	0	-	-	-	-	5
	extant area	1601	0	101	0	0	0	0	1913
south	#samples	1	-	-	-	-	-	-	1
	extant area	695	0	0	0	0	0	0	924
Coastal sand									
flat	#samples	25	-	-	-	-	-	-	25
	extant area	390	0	0	0	0	0	0	390
north	#samples	5	-	-	-	-	-	-	5
	extant area	202	0	0	0	0	0	0	202
intermediate	#samples	18	-	-	-	-	-	-	18
	extant area	454	0	0	0	0	0	0	454
south	#samples	7	-	-	-	-	-	-	7
	extant area	248	0	0	0	0	0	0	248
Tertiary alluvium									
flat	#samples	16	1	-	-	-	1	-	18
	extant area	13376	140	0	0	0	150	0	13864
north	#samples	0	0	-	-	-	-	-	0
	extant area	2045	33	0	0	0	0	0	2161
intermediate	#samples	9	-	-	-	-	-	-	9
	extant area	3894	0	0	0	0	0	0	4147
south	#samples	4	0	-	-	-	-	-	4
	extant area	2032	17	0	0	0	0	0	2091
Sedimentary (low quartz)									
flat	#samples	6	3	0	-	-	0	10	19
	extant area	1995	370	151	0	0	174	2461	5206
north	#samples	1	6	3	5	1	0	3	19
	extant area	974	928	925	759	739	821	2360	7506
intermediate	#samples	7	16	7	2	4	3	11	50
	extant area	2377	2105	1927	1570	1510	1970	5463	16923
south	#samples	2	8	8	2	0	0	8	28
	extant area	1219	901	937	760	767	909	2141	7633
Sedimentary (high quartz)									
flat	#samples	17	5	3	4	1	14	2	46
	extant area	16623	3427	1036	468	419	3438	982	26392
north	#samples	23	29	19	6	2	6	5	90
	extant area	17070	11071	6398	4403	2805	2646	1789	46183

Table 1. cont.

Substrate/terrain	Elevation	0–150	151–300	301–450	451–600	601–750	751–900	> 900	Total
intermediate	#samples	44	41	33	31	19	19	22	209
	extant area	33239	20982	12781	8942	6558	6961	4423	93886
south	#samples	21	23	25	16	9	6	10	110
	extant area	17074	11983	6704	4692	3464	3481	1982	49381
Rhyolite									
flat	#samples	6	0	-	-	-	-	-	6
	extant area	2363	73	0	0	0	0	0	2439
north	#samples	0	0	-	-	-	-	-	0
	extant area	1291	160	0	0	0	0	0	1452
intermediate	#samples	3	0	-	-	-	-	-	3
	extant area	3155	442	0	0	0	0	0	3598
south	#samples	1	0	-	-	-	-	-	1
	extant area	1440	142	0	0	0	0	0	1584
Granitoid volcanics									
flat	#samples	19	22	31	35	23	33	42	205
	extant area	3286	7397	11185	5523	2571	6357	16673	52992
north	#samples	11	19	34	32	24	15	21	156
	extant area	2521	8643	11613	7963	4292	4404	5869	45304
intermediate	#samples	21	43	49	66	55	59	26	319
	extant area	4982	18241	26008	18612	10007	9611	14232	101692
south	#samples	17	15	37	38	37	37	25	206
	extant area	2254	8841	13117	9572	5743	5092	7379	51997
Basalt									
flat	#samples	0	-	-	-	-	5	6	12
	extant area	112	0	0	0	0	587	1244	2040
north	#samples	0	0	-	-	-	0	3	3
	extant area	381	203	0	0	0	144	551	1321
intermediate	#samples	0	0	-	-	-	0	6	6
	extant area	420	453	0	0	0	534	1392	2932
south	#samples	0	0	-	-	-	2	4	6
	extant area	183	170	0	0	0	266	722	1438
Total #samples		**304**	**230**	**253**	**237**	**176**	**199**	**205**	**1604**
Total extant area		**140676**	**96866**	**93491**	**63460**	**39353**	**48020**	**69897**	**551763**

Field sampling methods

Vegetation was sampled in a total of 1032 0.04 ha quadrats, a standard size used by the National Herbarium of NSW, National Parks and Wildlife Service and State Forests of NSW in surveys of the coast and tablelands. These were generally square (20 × 20 m) except for some samples on linear landscape features such as beach dunes or riparian alluvium. Where these features were narrower than 20 m, quadrat dimensions were adjusted to ensure landform homogeneity within an area of 0.04 ha. All vascular plant taxa were recorded and allocated cover-abundance estimates on a six-point Braun-

Blanquet scale (Poore 1955). Plant identifications were verified where necessary by checking specimens at the National Herbarium. Records that could not be fully verified (due to inadequate specimens) were excluded from further analysis. Quadrats were searched as fully as possible, however some geophytic and ephemeral species may have escaped detection, depending on the presence of identifiable above-ground organs at the time of sampling. It seems unlikely that these omissions would affect analyses significantly because seasonal geophytes and ephemeral species occur at low frequencies usually at low local abundance in this region.

The height and projective foliage cover were estimated for up to four vertical vegetation strata if present: tree; small tree or tall shrub; shrub; and groundcover. The local terrain was described by measuring slope, aspect and horizon azimuths on eight points of the compass and by qualitative description of landform. Additional notes were made on soil texture and drainage, and evidence of recent disturbance (including fire, logging and physical damage).

Evaluation of additional data

In addition to the 1032 samples described above, a large volume of additional data were available from numerous surveys of local management areas (e.g. Gilmour 1983, Binns & Kavanagh 1990a) and regional surveys of particular habitats (e.g. Floyd 1982, Clarke 1989). These additional data were gathered using a range of different sampling methods which, in some cases, may preclude them from valid analysis with other data. Inclusion of incompatible data within a single analysis may cause results to be influenced more by methodological artefacts than florisitic similarities. Reduction of data to a level of detail that is common to all samples is a potential solution to some of these problems. For example, if some proportion of available samples lacked species abundance estimates or if different abundance measures were applied in different data sets, then all samples could be reduced to species presence/absence data for a common analysis. Differences in abundance measures therefore could not influence results. However, we rejected this approach because we believed variation in species abundance could be important in detecting significant vegetation patterns and because a large number of samples with reasonable coverage of the study area had a common abundance measure (Braun-Blanquet cover abundance). Instead, we set data evaluation criteria to exclude unsuitable samples from analysis.

As a minimal requirement, samples were required to be located on the Australian Map Grid with a precision of at least 100 m. In addition, the following sampling criteria were applied:

(I) Area of plot within the range 0.04–0.1 ha;

(II) Complete list of vascular plant species within the plot;

(III) Species abundances estimated on the six-point Braun-Blanquet cover-abundance scale.

The limits suggested in Criterion I were supported by trial data analyses in which the outcome of cluster analysis was not sensitive to variation in sample size between 0.04 and 0.1 ha. All samples met Criterion I except those of Floyd (1982), Gilmour (1983), Garven (1984), Benson (1994) and Clarke (unpubl.). The dimensions of plots were not

recorded in the first three of these surveys (Table 2), however, it is likely that most of Gilmour's (1983) samples fell within the 0.04–1.0 ha range (Gilmour, pers. comm.). The surveys of Benson (1994) and Clarke (unpubl.) used quadrats smaller than 0.04 ha.

With the exception of NPWS (unpubl. 1986) tree survey data, all samples met Criterion II (Table 2). However, it is likely that a few inconspicuous species may have been overlooked in some samples, particularly geophytes which may be absent above ground during certain seasons or years. In a few samples, species richness appeared to be low, particularly for less tractable taxa such as Poaceae, relative to other samples in similar locations and habitats. Most of these samples were linked to particular observers suggesting that some species may have been consistently overlooked. These samples were excluded to ensure precautionary maintenance of data quality.

A large number of samples failed to meet Criterion III (Table 2) because they had species presence/absence data only (e.g. Breckwoldt 1979, SFNSW unpubl.). Another large set of samples had abundance measures other than Braun-Blanquet cover-abundance (Table 2). Examples include qualitative species abundance classes (e.g. Floyd 1982, Gilmour 1983), species frequency scores based on nested quadrats (Outhred 1986), and surveys in which species were assigned multiple abundance estimates for respective strata but no overall estimate for the plot (e.g. Fanning & Mills 1990). In a few cases where raw cover values were estimated for each species (e.g. Dodson et al. 1988), these were converted to Braun-Blanquet cover-abundance scores. Extensive exploratory analyses were carried out to determine whether samples that failed to meet Criterion III could be allocated to the vegetation classes defined by analysis of cover-abundance data of other samples. The exploratory analyses involved the identification of indicator species from presence/absence data in the additional samples. The details of these analyses will not be reported here, but they generally failed to allocate presence/absence samples to classes with an acceptable level of certainty.

Of 2400 additional samples evaluated, 614 met the locational precision criterion and all three sampling criteria (Table 2). With one exception, samples that failed to meet the data evaluation criteria were in areas that were well covered by other samples. The exception involved the extensive area of dissected terrain in Wadbilliga and Bemboka National Parks. Only 30 samples in this area met all criteria while a further 173 samples (Outhred 1986) met all criteria except Criterion III. These 173 samples were included in a supplementary data analysis to provide an adequate description of vegetation patterns in this part of the region.

Botanical nomenclature

Botanical nomenclature was reviewed and standardised across all data sets. There were many instances in which two or more synonyms were applied to the same taxon in different data sets and these were updated to reflect currently accepted nomenclature (Harden 1990–93, and subsequent revisions). In other cases, some observers specified a subspecific or varietal taxon, while others did not. If these species were represented in the region only by a single subspecies or variety, the records were

Table 2. Additional vegetation data evaluated. Data sets marked * met all data evaluation criteria (see text).

Reference	Location surveyed	Number of samples	Species recorded	Plot size (ha)	Abundance measure
Benson 1994	Monaro grasslands	5	All vascular	0.01	Braun-Blanquet
Binns & Kavanagh 1990a*	Nalbaugh SF	62	All vascular	0.1	Braun-Blanquet
Binns & Kavanagh 1990b*	Nullica SF	91	All vascular	0.1	Braun-Blanquet
Breckwoldt 1979	Bermagui NR, Goura NR, Mimosa Rocks NP, Wallaga Lake NP	385	All vascular	0.1	Presence/absence
Clarke 1989*	NSW Coastal dunes	84	All vascular	0.04	Braun-Blanquet
Clarke unpubl.	Southern NSW saltmarsh	141	All vascular	0.0025	Braun-Blanquet
Dodson et al. 1988*	Tantawangalo catchment	30	All vascular	0.1	% Cover
Fanning & Clark 1991*	Jingera, Nullica SF	66	All vascular	0.1	Braun-Blanquet
Fanning & Fatchen 1990*	Wog Wog Ck	113	All vascular	0.1	Braun-Blanquet
Fanning & Mills 1989	South Rockton, Bondi SF	71	All vascular	0.1	Frequency index
Fanning & Mills 1990	Myanba Ck	107	All vascular	0.1	Qualitative index
Fanning & Mills 1991	Stockyard Ck	66	All vascular	0.1	Qualitative index
Floyd 1982	Eden rainforests	11	All vascular	undefined	Qualitative index
Garvin 1984	Ben Boyd (South) NP	26	All vascular	undefined	Qualitative index
Gilmour 1983	Nadgee NR	65	All vascular	undefined	Qualitative index
Lane et al. 1998*	Bermagui NR, Biamanga NP, Goura NR, Wallaga Lake NP	73	All vascular	0.1	Braun-Blanquet
Outhred 1986	Wadbilliga NP	173	All vascular	0.1	Frequency score
NPWS unpubl. 1986	South east NSW	183	Trees	0.1	Presence/absence
State Forests* (NSW)	Coolangubra Escarpment FR	22	All vascular	0.1	Braun-Blanquet
State Forests* (NSW)	Illawambra FR	21	All vascular	0.1	Braun-Blanquet
State Forests* (NSW)	Mt Poole FR	24	All vascular	0.1	Braun-Blanquet
State Forests* (NSW)	Waalimma FR	22	All vascular	0.1	Braun-Blanquet
State Forests* (NSW)	Yambulla FR	6	All vascular	0.1	Braun-Blanquet
State Forests (NSW)	Yambulla catchments	558	All vascular	0.1	Presence/absence

updated by adding the appropriate epithet. For species with more than one subspecific or varietal taxon in the region, the unresolved records were deleted if these were few in number relative to resolved records, or otherwise all of the records were reduced to the species level. A regional species list was compiled from the sample data and supplemented by additional records from the literature (e.g. Binns 1987) and herbarium collections (see Keith et al. 1999).

Cluster analyses and definition of floristic assemblages

A preliminary cluster analysis was carried out on a core set of 1066 samples for an interim forest assessment (Keith et al. 1995). The analyses were carried out using PATN computer programs (Belbin 1994) and were similar to those used in an earlier study by Keith & Sanders (1990). Compositional dissimilarity among samples was calculated using the symmetric version of the Kulzcynski coefficient applied to unstandardised cover-abundance data (Faith et al. 1987). An unweighted pair-group arithmetic averaging (UPGMA) clustering strategy was applied to the resulting association matrix (Belbin and McDonald 1993) to derive a hierarchical classification. Homogeneity analysis (Bedward et al. 1992b), a technique that measures the extent to which group splitting yields improvements in overall homogeneity of all groups based on inter-sample dissimilarities, was applied to the hierarchical classification. The trend of diminishing gains in homogeneity was used to identify a level in the hierarchy (dendrogram) from which lineages were to be interpreted for the definition of floristic groups. These lineages were interpreted at successively lower levels in the hierarchy by assessing differences between sister groups (Keith & Sanders 1990) with respect to diagnostic species, vegetation structure and physical attributes (elevation, aspect, parent material, distribution). Interpretation using these attributes is consistent with JANIS' (1996) criteria for forest ecosystem definition, viz. 'units should be defined in terms of floristic composition in combination with substrate and position in the landscape.' Floristic groups were recognised when further splitting failed to discernibly resolve variation in any of these factors. The number of groups in the classification was therefore limited by the identification of prominent differences in species composition, vegetation structure and physical habitat.

A nearest neighbour check was carried out to identify samples that may have been misclassified during the clustering procedure, an artefact that may sometimes occur in hierarchical clustering strategies (Belbin 1994). Samples with fewer than two of their five nearest neighbours within the provisional unit to which they were allocated were identified for further evaluation. Alternative allocations of these samples were considered by examining the group affinities of nearest neighbours and respective values of structural and environmental variables.

The classification was modified and refined with new data that became available after the interim forest assessment. As stated previously, the collection of new data was directed to fill gaps identified by iterative assessment of the sample stratification. Further analyses were conducted on an expanded data set to assign new samples to floristic groups in the existing classification and, where new variation was apparent, define additional groups. Consensus between four analyses was used to establish

relationships between new samples and the classification groups defined by analysis of the core data (Table 3). These included further cluster and nearest neighbour analyses as described previously, group centroid analyses and indicator species allocation analyses. Group centroid analyses were carried out using ALOC (Belbin 1987, 1994) to determine the five nearest group centroids to each new sample. Indicator species allocation analyses allocated new samples to classification units using the dendrogram as a decision rule structure for the presence or absence of species (Bedward & Keith unpubl.). The method delivers an indeterminate result for samples with no informative species or where different species give conflicting information on group membership.

Where cluster analysis agglomerated new samples into discrete dendrogram lineages, these were assessed against sister lineages and new floristic groups were recognised as described previously. The remainder of new samples were assigned to existing floristic groups using rules to assess consensus among the four alternative allocation analyses (Table 3). Four hundred and six of the 614 new samples met one or more of the consensus rules and were added to the core set of 1066 samples. Conversely, 208 of the new samples failed to meet any of the consensus rules indicating significant conflict between the four allocation analyses. In these cases, the new samples could not reliably be assigned to a floristic group and were excluded from further analysis to avoid the introduction of methodological artefacts into the results.

To address a significant gap in sample stratification, it was necessary to carry out supplementary analyses including samples from Outhred's (1986) survey of Wadbilliga National Park. Species abundance was estimated in these samples using a frequency index (Table 2) that was analytically incompatible with Braun-Blanquet cover-abundance estimates. In the supplementary analyses all data were reduced to presence/absence format and subject to cluster analysis and lineage interpretation as described previously. Lineage interpretation resulted in recognition of some new floristic groups recorded only in the Wadbilliga survey. The new groups accounted for 91 of Outhred's (1986) 173 samples. The remaining new Wadbilliga samples were then either assigned to existing floristic groups by consensus among the four allocation analyses (Table 3), accounting for a further 41 samples or excluded from further analysis if they could not be reliably assigned (41 samples). Thus, the total number of samples assigned to floristic groups was 1604, including 132 from the Wadbilliga data set.

Table 3. Consensus rules for assignment of new samples to existing floristic groups.

A new sample was assigned to an existing floristic group (Group x) if any of the following conditions were met:

1. Three or more of its five nearest neighbours belong to Group x;
2. Allocated to Group x by cluster analysis AND at least one of five nearest neighbours belongs to Group x AND closest centroid is Group x;
3. Allocated to Group x by cluster analysis AND at least one of five nearest neighbours in Group x AND indicator species analysis suggests exclusive membership of Group x;
4. Allocated to Group x by cluster analysis AND at least two of five nearest neighbour belong to Group x AND second closest centroid is Group x;
5. Allocated to Group x by cluster analysis AND at least two of five nearest neighbours belong to Group x AND indicator species analysis suggests membership of Group x and no more than three other groups.

Description of Floristic Assemblages

Floristic assemblages were assigned vernacular names to impart to readers a mental picture of the vegetation and its habitat or distribution. Names were composed of up to four parts. The last part of the name describes vegetation structure (e.g. rainforest, forest, woodland, scrub, heath, swamp, grassland). Other parts of the name may include a place name (e.g. Wadbilliga, Waalimma, Eden) or landform (e.g. coastal, hinterland, tableland) and/or terms describing understorey strata (e.g. layered, wet fern, dry grass, dry shrub). Where possible, comparisons were drawn with similar types of vegetation described in adjacent regions (e.g. Austin 1978, Forbes et al. 1982, Woodgate et al. 1994).

Each floristic assemblage was described using summaries of the sample data to produce profiles of species composition, vegetation structure and physical habitat. Diagnostic species were identified for each floristic group in a fidelity analysis of the final set of 1604 samples described above. Diagnostic species were defined by the extent to which their occurrence at regional and local scales discriminated the target assemblage from residual vegetation (pooled samples of all other assemblages) as shown in Table 4 (after Westhoff & van der Maarel 1978). Species' occurrences at regional scales were represented by their frequency among quadrats, while their local abundances were represented by median cover-abundance within quadrats. For a few assemblages not represented among the 1604 samples (i.e. groups confined to the Wadbilliga area, grassland and saltmarsh) it was necessary to carry out additional analyses on data that did not meet the criteria for inclusion in a combined analysis (Benson 1994, Outhred 1986, Clarke unpubl.).

Three categories of species were defined (Table 4): positive diagnostic species (those more likely to occur within the target floristic assemblage than in all others); negative diagnostic species (those unlikely to occur within the target assemblage but generally abundant elsewhere); and frequent species (those common or dominant in the target assemblage, but also likely to be common in others). All tree species recorded were listed in the descriptions of each floristic assemblage for context, irrespective of whether they met any of the three diagnostic criteria.

Table 4. Definitions of diagnostic species (modified from Westhoff & van der Maarel 1978). C/A refers to median Braun-Blanquet cover-abundance value (after Poore 1955).

		Residual Assemblages		
		Frequency < 0.5 AND C/A ≥ 2	Frequency ≥ 0.5 OR C/A < 2	Frequency = 0
Target Assemblages	Frequency ≥ 0.5 AND C/A ≥ 2	Frequent	Positive diagnostic	Positive diagnostic
	Frequency < 0.5 OR C/A < 2	Negative diagnostic	Uninformative	Positive diagnostic
	Frequency = 0	Negative diagnostic	Uninformative	-

The vegetation structure of each floristic assemblage was described by calculating the frequency of occurrence, mean height and percentage cover of each of four vertical life-form strata. The four strata were trees, small trees/tall shrubs, shrubs and herbs/graminoids.

The physical habitat of each floristic assemblage was characterised by calculating summary statistics for terrain variables, precipitation and parent material from the sample data. These summaries included: the frequency of occurrence on nine classes of parent material (Holocene coastal sands, Holocene riverine alluvium, Tertiary alluvium, Devonian high-quartz sedimentaries, Ordovician high-quartz sedimentaries, Devonian rhyolite, low quartz sedimentaries, Devonian granitoids and Tertiary and Devonian basalt); frequency of occurrence in four aspect classes (flat, north, west or east, and south); mean and interquartile ranges of altitude, slope and mean annual precipitation (latter calculated from modelled data, Table 5).

Gradient Analysis

Gradient analysis was carried out to gain an understanding of environmental relationships that may be useful predictors of the spatial distribution of floristic assemblages. A semi-strong hybrid multidimensional scaling ordination (Belbin 1991) was applied to the set of 1604 samples to examine relationships between floristic composition and environmental gradients. An association matrix was calculated using the symmetric form of the Kulzcynski coefficient, as for the cluster analysis described previously. Ratio regression was applied to association values less than 0.9, while ordinal regression was applied to values above this cut point. Ordinations were derived from 10 random starting configurations and a maximum of 50 iterations were allowed unless earlier termination was accepted when reductions in stress between successive iterations fell below 0.005. Ordinations were applied in an increasing number of dimensions to determine a parsimonious solution with comparatively low stress in a small, manageable number of dimensions. Vectors representing 19 terrain, substrate and climatic variables (Table 5) were fitted to the parsimonious ordination and their rank correlations with floristic trends were calculated. The variables used were: altitude; slope, two aspect indices, topographic roughness and position indices at three neighbourhood sizes each, local topographic position index, wetness index, solar radiation index, annual preciptation, precipitation of the driest and wettest months, mean maximum and minimum temperatures of the hottest and coldest months, respectively, and substrate nutrient index. The nutrient index was derived by arranging classes of parent material into an ordinal sequence, starting with the least fertile as follows: Holocene coastal sands; Tertiary alluvium, Devonian high quartz sedimentaries; Devonian rhyolite; Ordovician high quartz sedimentaries; Devonian granitoids; low quartz sedimentaries; Holocene riverine alluvium; and Tertiary/Devonian basalts.

Environmental and remote spatial data

A set of spatial data layers were rasterised to 25 m square grid cells for use in vegetation modelling. Terrain variables were derived from a 25 m grid digital elevation model supplied by the NSW Land Information Centre (Table 5).

Table 5. Spatial data layers used in mapping.

Spatial Variable	Description
Terrain	
Altitude	Elevation above sea level (metres)
Slope	Inclination from horizontal (degrees)
Aspect	Deviation from grid north perpendicular to slope (degrees)
Sine Aspect Index	Continuous index (0–100) calculated as 100 times sine of half aspect value in degrees (flat sites allocated missing values)
Ordinal Aspect Index	Categorical index of aspect (0: flat, 1: 301–30°, 2: 211–300°, 3: 31–120°, 4: 121–210°)
Solar Radiation Index	Continuous index representing topographic exposure to solar radiation calculated from slope, aspect, horizon azimuth and latitude. Varies below 100 for sheltered sites and above 100 for exposed sites
Wetness Index	Continuous index representing the volume of water draining to a given point in the landscape (after Moore et al. 1993)
Local Topographic Position (S)	Continuous index (0–100) representing proportional distance between local ridge (100) and local gully (0) (after Skidmore 1990)
Neighbourhood Topographic Position (250 m)	Difference between altitude of a central grid cell and mean altitude of surrounding cells within a 250 × 250 m neighbourhood
Neighbourhood Topographic Position (500 m)	Difference between the altitude of a central grid cell and mean altitude of surrounding cells within a 500 × 500 m neighbourhood
Neighbourhood Topographic Position (1000 m)	Difference between the altitude of a central grid cell and mean altitude of surrounding cells within a 1000 × 1000 m neighbourhood
Neighbourhood Topographic Roughness (250 m)	Standard deviation of altitude within a neighbourhood of 250 × 250 m
Neighbourhood Topographic Roughness (500 m)	Standard deviation of altitude within a neighbourhood of 500 x 500 m
Neighbourhood Topographic Roughness (1000 m)	Standard deviation of altitude within a neighbourhood of 1000 × 1000 m
Climate	
Annual Rainfall	Mean total yearly rainfall (mm)
Rainfall of Wettest Month	Maximum mean monthly rainfall (mm)
Rainfall of Driest Month	Minimum mean monthly rainfall (mm)
Minimum Temperature of Coldest Month	Mean minimum monthly temperature (°C)
Maximum Temperature of Hottest Month	Mean maximum monthly temperature (°C)
Substrate	
7-class Parent Material	Major geological formations
28-class Parent Material	Dominant lithologies
106-class Parent Material	Lithological classes
Land cover	
Vegetation Structure	Major vegetation formations (excluding temperate rainforest) determined from aerial photos
Temperate Rainforest	Rainforest determined from aerial photos
Forest Types	Baur (1989) types and mosaics interpreted from aerial photos
Extant Native Vegetation Cover	Presence of extant native vegetation determined from Landsat TM
Location	
Distance from Coast	Shortest distance from coast (metres)
Easting	Australian map grid
Northing	Australian map grid

The derived variables represented topographic position, relief, shelter and soil moisture at varying spatial scales.

Climatic surfaces (Table 5) were derived using ESOCLIM (Hutchinson 1989). The sparse distribution of weather stations within the region, and consequent scarcity of weather data, precluded quantitative evaluation of the climatic surfaces. Modelled temperature surfaces were very closely related to altitude and patterns due to local frost hollows were likely to be under-represented. Similarly, rainfall surfaces possibly underestimated regional orographic effects, although intuitively expected patterns were evident.

Spatial data for parent material supplied by the Bureau of Resource Sciences were based on a revision of earlier maps by Barnes & Herzberger (1975) and Beams & Hough (1984) and recent field observations. The classification was modified to distinguish coastal sands from other Holocene alluvium; Lochiel Basalt from associated Devonian lithologies; and Genoa Sandstone beds from other Devonian sediments (Barnes & Herzberger 1975). The final classification included 106 lithological units within the Eden region. Related units were lumped according to dominant lithology into 28 classes and these were lumped further into 7 major formations to provide three hierarchical spatial coverages of substrate (Table 5).

A GIS coverage differentiating native vegetation from cleared land and plantations of exotic species was prepared by manual interpretation of a Landsat TM image taken in 1989 and a map of existing plantations. This coverage was used as training data for a spectral classification of a Landsat TM image taken in 1994. It was assumed, consistent with field observations, that negligible land clearance occurred between 1994 and 1998.

A GIS coverage differentiating major structural types of native vegetation was prepared by manual interpretation of 1:25 000 scale black and white aerial photographs flown in 1963 (Table 5). For small parts of the area where these were unavailable photographs flown in 1979 and 1990 were used. Mapped occurrences of various structural types were checked using the sample data and observations gathered during field traverse. A separate coverage of rainforest was prepared from colour aerial photographs flown in 1994 as part of the Eden CRA old growth mapping study.

Forest Type maps (Baur 1989) prepared by State Forests of NSW and by National Parks and Wildlife Service were also included in the spatial data set for modelling.

Attribute values were extracted from each spatial data layer for all samples to be used in spatial modelling and validation. Samples were located in the field to a resolution of 100 m. They were assigned to a 25 m × 25 m pixel which had an altitude closest to the mean value within the relevant 100 m grid cell (4 × 4 pixel neighbourhood). This assignment procedure was designed to minimise errors in relation to the spatial data layer (digital elevation model) from which most others were derived.

Spatial Interpolation and Mapping

A hybrid decision tree/expert system technique was selected as the preferred approach for modelling the spatial distribution of the 79 floristic groups (map units). This technique describes the distribution of map units using decision rules that comprise a series of quantitative statements about spatial variables connected by conjunctions. The distribution of each map unit may be described by one or more mutually exclusive rules. Reasons for choice of this method include:

- the method is explicit and repeatable relative to intuitively based mapping techniques;
- the method is free from statistical constraints and assumptions about the structure of the data;
- the method is efficient because sets of decision rules are developed simultaneously for all map units, rather than individually; and
- the method allows for intervention by experts in an explicit manner through the choice and design of decision rules.

This latter capability is a major strength because it provides a framework for incorporating non-formal expert knowledge into the map. This kind of knowledge is difficult to build into statistical models, which traditionally rely upon quantitative sample data (e.g. Austin et al. 1984). While intuitive mapping allows qualitative knowledge to be incorporated, this generally occurs in the absence of an explicit framework (e.g. Keith & Benson 1988) such as that offered by a decision rule approach.

The main disadvantage of decision tree models relative to parametric models (e.g. generalised linear and additive models) is that they utilise fewer and fewer samples as more variables are fitted. Consequently, inadequate sampling of environmental space may be more limiting, at least superficially, for decision tree models. Statistical models rely upon environmental relationship established across the data set as a whole and consequently these are called upon to make predictions where sampling intensity is low. Comparative studies on the prediction of distributions of individual species suggest that generalised linear models and generalised additive models return slightly more accurate predictions than decision tree models (Ferrier & Watson 1997). However, these trials excluded expert intervention, a major strength of the approach employed here. In a comparative species modelling study, Elith et al. (1998) concluded that expert knowledge is likely to be useful, at least in the selection of appropriate variables for modelling. However, no comparative studies have yet been carried out on the modelling of multi-species assemblages.

Interactive modelling software (ALBERO) was developed to explore and implement alternative sets of decision rules. The software generates decision rules by statistical induction and facilitates expert intervention at various stages of model development. At each node in the decision tree, ALBERO displays all significant statements that discriminate different floristic classes by spatial variables (within a user-specified critical value) and nominates appropriate thresholds for discrimination. Significance is calculated using the Chi-squared statistic. For continuous and ordinal variables, nodes

are always split dichotomously at the significant value closest to the midpoint of variation. Non-ordinal categorical variables will split nodes into as many branches as account for significant discrimination of map units. Where two or more spatial variables discriminate ecosystems significantly, the user chooses a selection. Users may reduce the critical value to inspect a wider range of potential splits. A decision rule (ie. branch of the decision tree) is complete when there are no further significant splits at the nominated critical value.

ALBERO accommodates explicit expert intervention in the modelling process by offering a choice between multiple significant variables at each node, facilitating exploration of alternative tree structures, allowing non-significant splits to be forced, and allowing definition of data-free terminal nodes. The latter facility accommodates qualitative observations by experts where no quantitative data are available.

A decision-tree model of floristic groups in the Eden region was developed using 1450 of the 1604 allocated samples. Use of these samples assumed that no substantial vegetation changes occurred during the sampling period (1987–1997). Significant regional-scale spatial variables (parent material, rainfall and temperature) were selected at early stages of tree construction, while attention turned to local-scale variables (e.g. terrain) to discriminate smaller groups of samples representing different map units. The model was developed iteratively by checking distributions predicted by particular sets of rules and adjusting tree structure as necessary (see below). Terminal nodes were allocated to the map unit represented by the greatest number of samples. Where there was a tie, expert knowledge was applied to choose a suitable option.

The final set of decision rules was applied to the full set of spatial data layers (Table 5) to allocate all 25 m grid cells in the study area to a map unit. Several small polygons remained unassigned to map units because some of the finest-scale (106–class) geological units were not sampled within the relevant climatic and terrain envelope. These polygons were assigned to a map unit either by using data on a related geological class or by assigning cells to the same map unit as their nearest assigned neighbour. The model output was then smoothed to remove small artefactual features. The resulting map represented the pre-1750 distribution of floristic groups, a baseline required for the Comprehensive Regional Assessment (JANIS 1996). This was cut using the Landsat coverage of extant native vegetation cover (Table 5) to derive the extant distributions of map units.

Map validation

Three complementary approaches were used in map validation: qualitative checking, description of map reliability and quantitative accuracy assessment. Qualitative checking procedures were incorporated into the development of the map. The decision-tree model was broken down into manageable components for proofing. The checking process was carried out by an experienced field botanist (DK) and consisted of the following steps.

(1) A small number of rules (5–12) were extracted from the model and implemented on the spatial data to display the distribution of respective map units.

(2) The mapped distributions were examined in relation to the regional distribution of their samples.

(3) The fine-scale distributions of map units were examined with reference to topographic maps to determine whether appropriate landscape relationships were reflected (e.g. that sheltered gullies generally support either similar or more mesic vegetation than adjacent ridges, but not less mesic vegetation).

(4) The sources of all identified anomalies were traced to particular nodes in the decision tree and the sample data were examined to explore alternative rule pathways below the node identified.

(5) The model and map were revised and proofing steps 1–5 were repeated until all identified anomalies were resolved.

When model development was well advanced, further refinements were sought from two other experienced field botanists (Doug Binns, State Forests of NSW; Jackie Miles, consultant, Brogo).

Sampling density was used to describe map reliability across the study area. The 1450 samples used to construct the decision tree model were used to calculate the number of samples within a 5 km^2 radius of each 100 m grid cell. Sampling density was calculated by dividing the number of samples by the area of extant native vegetation in each circular neighbourhood. Six classes of sampling density were defined in terms of the number of samples per square kilometre of extant native vegetation. The distribution of these classes was mapped in all parts of the study area supporting extant native vegetation.

One hundred and fifty-four (approximately 10%) of the 1604 samples selected for data analysis were withheld from modelling for accuracy quantification. These validation samples were used to test model predictions against independent observations at varying spatial scales relevant to map usage. These spatial scales were represented by spatial neighbourhoods of varying size around the validation samples. Validation samples were selected at random from all map units excluding those with less than 20 samples so as not to unduly constrain modelling options for these less common units.

The principal aim of accuracy quantification was to determine the likelihood that selection of an area to represent a given floristic assemblage in a reserve actually contained the assemblage predicted on the map. Planning units used for reserve selection in the Eden Comprehensive Regional Assessment varied in size from approximately 20 ha to 240 ha with a median size around 100 ha. Validation samples were thus compared to mapped units within circular neighbourhoods with the following radii and area to determine error rates at spatial scales relevant to map usage: 100 m (3 ha); 200 m (12 ha); 300 m (28 ha); 400 m (50 ha); 500 m (79 ha); 600 m (112 ha); 700 m (153 ha); 800 m (201 ha); 900 m (253 ha); and 1 000 m (314 ha). The percentages of correct and incorrect matches were recorded as an estimate of map accuracy and statistical errors were calculated from the binomial distribution.

Results

Classification and description of floristic assemblages

The hierarchical classification derived from cluster analysis is summarised in a simplified dendrogram (Fig. 4). Thirty-three dendrogram lineages were identified for further interpretation using homogeneity analysis. A number of these lineages were not split further, while others were resolved into several floristic assemblages that were related to qualitatively different habitats defined by substrate and position in the landscape. The following example shows how complex variation in one dendrogram lineage was resolved into six floristic groups (refer to first six groups in Fig. 4).

The parent lineage contains 90 samples with a diverse range of dry forest species. Samples encompass altitudinal range of 15–915 m on a range of granitoid, sandstone, mudstone and alluvial parent materials, across all aspects on flat and dissected terrain. Samples are distributed throughout the coast and southern parts of hinterland and tableland range.

The first split segregated a group of samples restricted to sandstone on steep northern and western aspects of Mt Imlay, Nungatta Mountain and Bondi Gulf at 330–750m elevation. Samples indicate a forest less than 20 m tall dominated by *Eucalyptus agglomerata* and prominent ground stratum. Further splitting failed to resolve substantial variation within this group. It was therefore recognised and mapped (map unit 50 in Fig. 4).

The second split resulted in two further groups. The first of these included samples distributed widely on coastal ranges and inland mountains which, when split again, yielded one subgroup dominated by *Eucalyptus sieberi* and largely confined to tonalite lithology in the Mumbulla Mountain area, and another subgroup dominated by *Eucalyptus agglomerata, Eucalyptus sieberi* and *Allocasuarina littoralis* that was more widespread on sedimentary lithologies of coastal and hinterland ranges. Further splitting failed to resolve substantial variation within these subgroups which were recognised and mapped (map units 48 and 49, respectively, in Fig. 4).

The remaining sample groups in the lineage were resolved into three map units in a similar manner. They were: 46A (low forest dominated by *Eucalyptus consideniana* restricted to granitoids and Tertiary alluvium in the Timbillica area); 46B (taller forest dominated by *Corymbia gummifera* and *E. sieberi* confined to sediments and Tertiary alluvium on the coastal strip); and 47 (taller forest dominated by *Angophora floribunda* and *E. sieberi* confined to sediments south of Pambula).

Alternative interpretations of the hierarchy yielding greater and fewer map units were considered in the manner described above. A total of 79 map units were recognised in the vegetation classification. These included 61 floristic groups that were interpreted from the 33 dendrogram lineages identified initially using homogeneity analysis. Six additional assemblages were recognised in the supplementary analysis of presence/absence data including samples from Wadbilliga National Park. A further nine units including eight estuarine wetlands and one grassland were recognised independently of the numerical analyses and described either using available

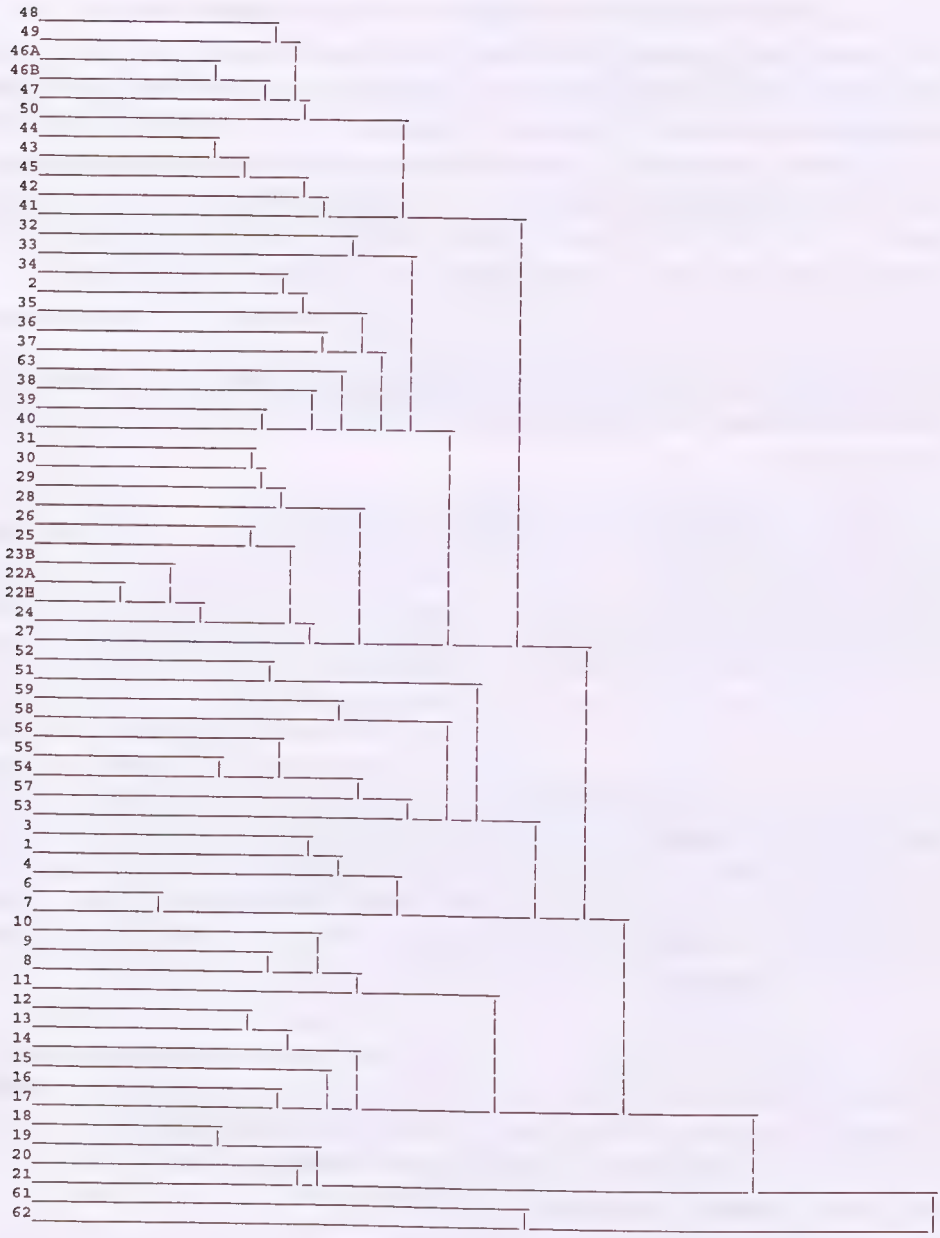

Fig. 4. Simplified dendrogram showing floristic relationships based on samples with Braun-Blanquet cover-abundance estimates.

qualitative observations from the field or the literature, or using available quantitative data that were unsuitable for inclusion in the cluster analyses (e.g. Benson 1994, Clarke unpubl.)

The Appendix describes the floristic composition, vegetation structure, physical habitat and distribution of samples for each map unit. Four of the 79 map units (67–70) were restricted to estuaries below low tide mark (sea grass meadows). A further four units (63–66) were estuarine wetlands associated with the high tide mark. Of the remainder, 47 map units were forests dominated by eucalypts, six were rainforests or scrubs with rainforest affinities, 10 were shrublands or heathlands, 3 were swamps and 2 were grasslands. The 47 types of eucalypt forest varied from tall forests with mesophyllous shrub, fern or herbaceous understories, to intermediate and dry forests with grassy or sclerophyllous shrub understories.

There was close correspondence between the current floristic classification and that based on an earlier analysis of a smaller data set (369 samples, Keith & Sanders 1990). Thirty-four floristic assemblages were related on a 1:1 basis to units defined in the earlier study (Table 6). In five cases two (map units 5 and 6, 16 and 17, 44 and 45, 46A and 46B) or three (e.g. map units 11, 12 and 15) of the currently recognised assemblages corresponded to a single unit in the earlier classification (Table 6). The additional data now available allowed resolution of poorly sampled vegetation classes that were not previously recognised. Conversely, three of the currently recognised assemblages (map units 26, 35 and 56) corresponded with two previously recognised units. In these cases, additional sampling suggested there was greater overlap between the units in the earlier classification than previously recognised. Three of Keith and Sanders' (1990) communities were originally defined in the absence of quantitative data and were resolved as follows: Community 18 in the Bega and Towamba valleys (resolved into map units 18–21); Community 19 on the Monaro Tableland (resolved into map units 22–24); and Community 41, the estuarine complex (resolved into map units 63–70). Eleven assemblages had locally restricted distributions and were not previously sampled (map units 2–4, 28, 29, 39, 40, 52, 54, 60 and 62). The remaining seven previously unrecognised units (22B, W1–W6) were introduced to describe vegetation in the Wadbilliga-Numeralla area which was not included in the previous study (Table 6).

Regional flora and species richness

A total of 1522 vascular indigenous plant taxa were represented by confirmed records in the region (Keith et al. 1999). A further 136 taxa were recorded, but require confirmation. Some previous records were determined to be erroneous identifications, while a number of others remain doubtful. Three hundred and seventy-five introduced plant taxa were recorded, but this is likely to underestimate the regional alien flora because highly disturbed habitats that are favourable to such species, such as pastures and wastelands, were under-represented in sampling (Keith et al. 1999).

Species richness of terrestrial vegetation varied from 2 to 81 per 0.04 ha, with a regional mean of 30 and inter-quartile range of 23–40. There was considerable variation in species richness between floristic assemblages (Table 7). The most species-

Table 6. Correspondence between floristic assemblages described in this study with those described by Keith and Sanders (1990).

This study	Keith & Sanders(1990)	This study	Keith & Sanders(1990)
1	1	44	24
2	not sampled	45	24
3	not sampled	46A	28
4	not sampled	46B	28
5	2(I)	47	29
6	2(I)	48	26(I)
7	2(II)	49	26(I)
8	3	50	20
9	4	51	25
10	5	52	not sampled but referable to 25
11	not sampled but referable to 6	53	35
12	6	54	not sampled but referable to 33
13	9(I)	55	33
14	9(II)	56	34, 36
15	6	57	39
16	7	58	8
17	7	59	40
18	not sampled but referable to 18	60	not sampled
19	not sampled but referable to 18	61	31
20	not sampled but referable to 18	62	not sampled
21	not sampled but referable to 18	63	not sampled but referable to 41
22A	not sampled but referable to 19	64	not sampled but referable to 41
22B	outside study area	65	not sampled but referable to 41
23A	not sampled but referable to 19	66	not sampled but referable to 41
23B	not sampled but referable to 19	67	not sampled but referable to 41
24	38	68	not sampled but referable to 41
25	20	69	not sampled but referable to 41
26	37, 21	70	not sampled but referable to 41
27	13	W1	outside study area
28	not sampled but referable to 14	W2	outside study area
29	not sampled but affinities with 7 and 22	W3	outside study area
		W4	outside study area
30	17	W5	outside study area
31	14	W6	outside study area
32	30		
33	26(II)		
34	12		
35	16, 15		
36	32		
37	10		
38	11		
39	not sampled but referable to 11		
40	not sampled		
41	23		
42	27		
43	22		

rich assemblages (map units 19 and 34) were semi-mesic assemblages with a high diversity of both shrubs and herbs contributing on average to more than 45 species per 0.04 ha. Other species-rich assemblages with more than 40 species per 0.04 ha (map units 13, 17, 18 and 30) generally had large numbers of herb species in the ground stratum but fewer shrub species. Mesic eucalypt forests (map units 11–19) and dry grassy eucalypt forests of the coastal valleys (map units 20–21) and hinterland (map units 27–31 and 35) had species richness consistently above 32 species per 0.04 ha (Table 7). Some intermediate forests (map units 34 and 37) and dry shrubby forests at low elevation (map units 46A and 46B) also had richness values in this range. These low elevation assemblages excepted, dry shrubby eucalypt forests (map units 25, 41–50) generally have 20–30 species per 0.04 ha. In low rainfall areas, the dry shrubby forests on quartz-rich sediments (map units 25, 50, W1–W5) and dry grassy forests and woodlands on the tableland had low levels of species richness (16–24 species per 0.04 ha, and 11 per 0.01 ha for Map Unit 23A). Rainforests (map units 1, 5–8), layered forests (map units 2, 3, 9 and 10) and heathlands (map units 53–56 and 61) had variable levels of species richness, the coastal assemblages generally having more species than the elevated montane assemblages (Table 7). Freshwater swamps (map units 57–60) had moderate richness levels, while estuarine wetlands (map units 63–70) and beach strand (map unit 62) generally had very few species.

Gradient Analysis

Four ordination axes were required to summarise regional floristic variation parsimoniously (stress values of 0.33, 0.26 and 0.20 were returned for configurations in 2, 3 and 4 dimensions, respectively). Altitude had the highest correlation with floristic composition, while minimum temperature of the coldest month, annual rainfall and rainfall of the driest month were also strongly correlated with composition (Table 8). These relationships reflect regional scale patterns in vegetation. The variables may be expected to correlate strongly with each other (Fig. 5), given orographic influences on rainfall and adiabatic lapse related to altitude, even though rainshadows and frost hollows may cause subregional deviations from general altitudinal relationships. A suite of topographic variables including neighbourhood indices at all three scales and slope were moderately correlated with floristic composition (Table 8), as was substrate nutrient index. These relationships reflect primarily local-scale patterns in vegetation. While the topographic variables were correlated to varying degrees with each other, substrate nutrient index was largely unrelated to all other environmental variables examined (Fig. 5). There may be additional relationships between floristic composition and substrate that were not adequately represented by the simple ordinal nutrient index. Variables representing the finest scale variation in topography (e.g. aspect indices, radiation, local topographic position and wetness) were the least correlated with floristic composition. This may be due in part to the poor representation of complex fine scale relationships in a large data set reduced to 4 dimensional space.

Table 7. Native species richness of major vegetation formations at scales ≤ 0.1 ha.

Floristic assemblage	Species richness mean	se	n	Sample area (ha)
1	28	5	6	0.04
2	32	3	5	0.04
3	27	3	13	0.04
4	8	2	3	0.04
5	47	-	1	0.04
6	31	2	13	0.04
7	28	3	10	0.04
8	17	2	5	0.04
9	21	2	11	0.04
10	29	1	80	0.04
11	31	1	18	0.04
12	33	2	31	0.04
13	40	1	70	0.04
14	33	2	36	0.04
15	33	1	132	0.04
16	35	1	32	0.04
17	43	3	19	0.042
18	42	2	16	0.04
19	48	2	38	0.04
20	39	1	48	0.04
21	35	3	28	0.04
22A	16	1	5	0.04
22B	13	3	3	0.04
23A	11	2	5	0.01
23B	17	3	14	0.04
24	26	2	20	0.04
25	22	1	10	0.04
26	32	2	34	0.04
27	38	2	5	0.04
28	34	2	10	0.1
29	39	3	17	0.1
30	42	2	17	0.04
31	38	1	54	0.04
32	31	2	42	0.04
33	27	1	55	0.04
34	46	3	24	0.04

Floristic assemblage	Floristic mean	Species richness se	n	Sample area (ha)
35	37	1	51	0.04
36	22	2	6	0.04
37	35	2	17	0.04
38	22	14	3	0.04
39	37	7	5	0.0
40	27	9	4	0.04
41	21	1	28	0.04
42	30	1	64	0.04
43	34	2	13	0.04
44	30	1	29	0.04
45	29	3	23	0.04
46A	36	0	24	0.04
46B	35	2	19	0.04
47	26	1	19	0.04
48	28	2	19	0.04
49	28	1	48	0.04
50	21	3	5	0.04
51	34	4	14	0.1
52	24	2	8	0.1
53	17	2	21	0.04
54	37	3	6	0.04
55	35	4	8	0.04
56	29	4	5	0.04
57	28	4	9	0.04
58	30	4	14	0.04
59	29	4	7	0.04
60	39	7	3	0.04
61	17	1	41	0.04
62	5	1	30	0.04
63	22	2	4	0.04
64	4	0	141	0.0025
W1	18	1	28	0.05
W2	20	1	15	0.05
W3	20	2	13	0.05
W4	24	2	6	0.05
W5	32	1	22	0.05
W6	33	3	7	0.05

Table 8. Rank correlations of floristic vectors fitted to 4-dimensional ordination space with the environmental variables they represent. Abbreviations for variables refer to Fig. 5.

Environmental Variable	Abbreviation	Correlation
Altitude	Alt	0.657
Minimum Temperature of Coldest Month	Min.T	0.587
Annual rainfall	Ann.R	0.559
Rainfall of Driest Month	Min.R	0.545
Neighbourhood Topographic Roughness (500 m)	Rug.500	0.386
Neighbourhood Topographic Roughness (1000 m)	Rug.1000	0.385
Neighbourhood Topographic Roughness (250 m)	Rug.250	0.384
Slope	Slp	0.371
Rainfall of Wettest Month	Max.R	0.363
Substrate Nutrient Index	Sub	0.335
Maximum Temperature of Hottest Month	Max.T	0.335
Neighbourhood Topographic Position (500 m)	Top.500	0.306
Neighbourhood Topographic Position (1000 m)	Top.1000	0.292
Sine Aspect Index	Asp.s	0.263
Neighbourhood Topographic Position (250 m)	Top.250	0.240
Solar Radiation Index	Rad	0.237
Wetness Index	Wet	0.207
Local Topographic Position	Top.1	0.174
Ordinal Aspect Index	Asp.o	0.127

Vegetation model and map

A hierarchical set of 470 decision rules was developed iteratively to describe the distribution of the 79 map units. Each map unit had between one and 31 rules describing its distribution. The highest order node in the decision tree (Fig. 6) was split according to major structural formations identified from aerial photopattern (rainforest, eucalypt forest, scrub, riparian vegetation, heath, grassland, treeless swamp and estuarine vegetation). Rainforest units were distinguished from one another using classes of aerial photopattern and rule thresholds for rainfall and elevation. The eucalypt forest node was split according to 8-class parent material and each parent material node was in turn segregated using the most informative regional-scale variables (Fig. 6). These included: mean rainfall of the driest month for granitoid substrates, the most widespread parent material in the region; elevation for high-quartz sedimentary rocks; finer scale geological units for basalt and low-quartz sedimentary rocks; and geographic trends for alluvial substrates. Lower order statements in rules describing the distribution of eucalypt-dominated map units were, in most cases, based on local terrain, substrate and eucalypt aerial photopattern. Three scrub map units were distinguished by aerial photopattern and parent material, while aerial photopattern and mean annual rainfall (Fig. 6) distinguished the three riparian units. Heathlands and grassland were segregated using elevation and aerial photopattern, while estuarine units were distinguished on the basis of aerial photopattern.

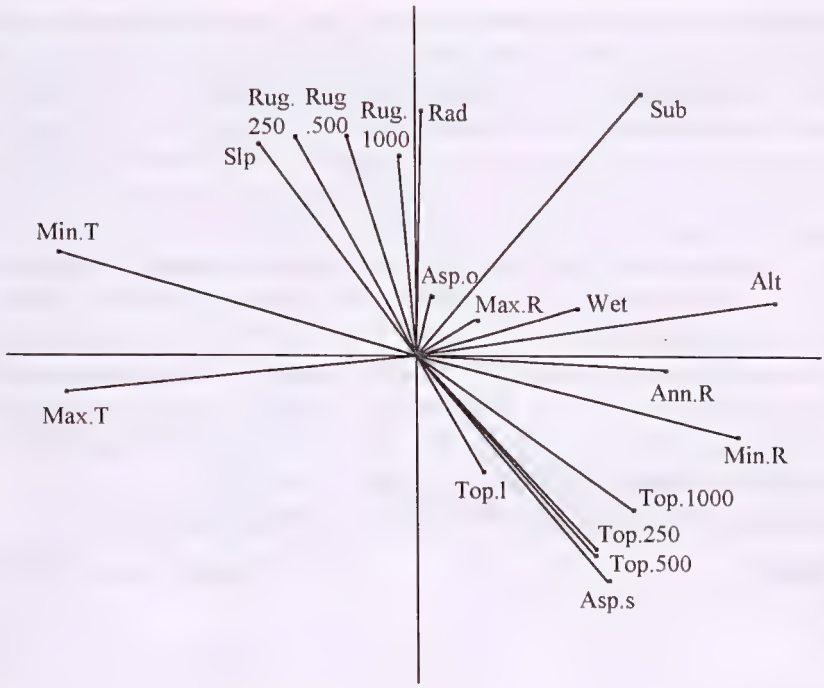

Fig. 5. First two axes of 4-dimensional ordination showing vectors representing environmental gradients in floristic composition. Refer to Table 8 for key to abbreviations.

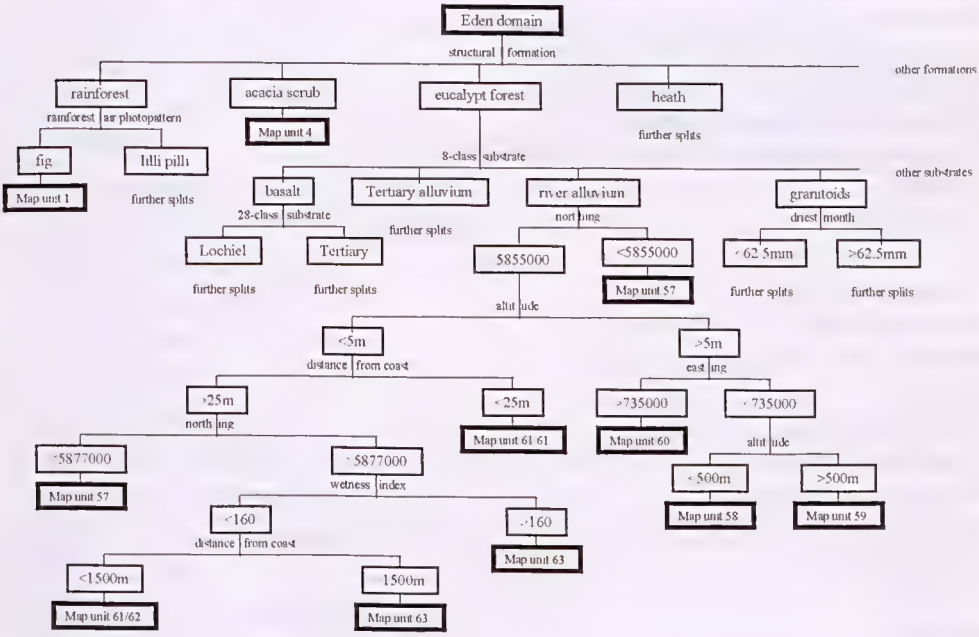

Fig 6. Principal nodes and branches in the decision tree model.

The spatial variables that were most frequently invoked in decision rules were major structural formations (aerial photopattern) and 8-class parent material (Table 9), reflecting their position high in the hierarchy of the decision tree (Fig. 6). Other variables invoked frequently in rules included elevation, mean annual precipitation, mean precipitation of the driest and wettest month, 28-class parent material, mean maximum temperature of the warmest month and topographic position within a 5 x 5 cell neighbourhood (Table 9). Slope, aspect indices and forest type were seldom invoked in decision rules. The frequency with which environmental variables were invoked in decision rules generally reflected the strength of their correlation with floristic composition (Table 8 cf. Table 9). Parent material (8 classes) had a high frequency in decision rules, but a lower ranking correlation with floristic composition. This may reflect the loss of information which occurred with the ordinal transformation of substrate classes that was necessary for vector fitting. Table 10 gives some examples to illustrate different rules used in mapping.

Table 9. Frequency with which spatial variables were invoked in decision rules.

Spatial Variable	% decision rules with variable
Terrain	
Altitude	84
Slope	4
Sine Aspect Index	1
Ordinal Aspect Index	1
Solar Radiation Index	19
Wetness Index	18
Local Topographic Position (S)	6
Neighbourhood Topographic Position (250 m)	22
Neighbourhood Topographic Position (500 m)	11
Neighbourhood Topographic Position (1000 m)	20
Neighbourhood Topographic Roughness (250 m)	13
Neighbourhood Topographic Roughness (500 m)	7
Neighbourhood Topographic Roughness (1000 m)	19
Climate	
Annual Rainfall	64
Rainfall of Wettest Month	57
Rainfall of Driest Month	66
Minimum Temperature of Coldest Month	36
Maximum Temperature of Hottest Month	16
Substrate	
8-class Parent Material	93
28-class Parent Material	48
106-class Parent Material	17
Land cover	
Vegetation Structure	100
Forest Types	1
Location	
Distance from Coast	10
Easting	10
Northing	15

Table 10. Example decision rules.

IF Vegetation Formation = eucalypt forest
AND Parent Material (8 class) = basalt
AND Parent Material (28 class) = Devonian basalt
AND Annual rain ≤ 900 mm
THEN map unit = 19

IF Vegetation Formation = eucalypt forest
AND Parent Material (8 class) = granitoids
AND Driest month <= 62.5 mm
AND Altitude ≤ 435 m
AND Driest month > 50.5 mm
AND Roughness (1000 m) ≤ 36.5 m
AND Driest month ≤ 56.5 mm
AND Parent Material (28 class) = Gabo adamellite OR Wallagaraugh adamellite
AND Annual rain ≤ 922.5 mm
AND Roughness (250 m) ≤ 5.5 m
THEN map unit = 26

IF Vegetation Formation = eucalypt forest
AND Parent Material (8 class) = granitoids
AND Driest month ≤ 62.5 mm
AND Altitude ≤ 435 m
AND Driest month > 50.5 mm
AND Roughness(1000 m) ≤ 36.5 m
AND Driest month ≤ 56.5 mm
AND Parent Material (28 class) = Gabo adamellite OR Wallagaraugh adamellite
AND Annual rain ≤ 922.5 mm
AND Roughness (250 m) > 5.5 m
THEN map unit = 46A

IF Vegetation Formation = eucalypt forest
AND Parent Material (8 class) = granitoids
AND Driest month ≤ 62.5 mm
AND Altitude ≤ 435 m
AND Driest month > 50.5 mm
AND Roughness (1000 m) ≤ 36.5 m
AND Driest month > 56.5 mm
AND Parent Material (106 class) = Dgbb OR Dgic OR Dgkk OR Dgpp OR Dgur
AND Topographic position (250 m) ≤ 72.5 m
AND Topographic position (500 m) ≤ 98.5 m
THEN map unit = 17

IF Vegetation Formation = eucalypt forest

Table 10. cont.

AND Parent Material (8 class) = granitoids

AND Driest month £ 62.5 mm

AND Altitude > 435 m

AND Altitude ≤ 796 m

AND Annual rain > 954 mm

AND Parent Material (28 class) = granodiorite

AND Altitude ≤ 643.5 m

AND Parent Material (106 class) = Dgdy OR Dgkk

AND Altitude > 492 m

AND Wetness index > 126

THEN map unit = 13

IF Vegetation Formation = eucalypt forest

AND Parent Material(8 class) = high quartz sediments OR rhyolite

AND Altitude ≤ 372.5 m

AND Annual rain ≤ 911.5 mm

AND Topographic position (1000 m) ≤ 149.5 m

AND Parent Material (28 class) = Adaminaby sandstone OR rhyolite

AND Driest month > 52.5 mm

AND Maximum temperature > 25.5°C

AND Wetness index > 141

THEN map unit = 13

IF Vegetation Formation = eucalypt forest

AND Parent Material (8 class) = low quartz sediments

AND Parent Material (106 class) = Db

AND Driest month ≤ 58.5 mm

AND Maximum temperature ≤ 25.1°C

AND Topographic position (250 m) ≤ 76 m

AND Solar radiation index ≤ 115

THEN map unit = 13

IF Vegetation Formation = eucalypt forest

AND Parent Material(8 class) = tertiary alluvium

AND Easting > 725000

AND Maximum temperature ≤ 23.6°C

AND Wetness index > 156.5

THEN map unit = 37

The decision rules were implemented on the spatial data layers to produce vegetation map (inside back cover). Floristic assemblages 61 and 62 were mapped a mosaic because stands of assemblage 62 were restricted to narrow beach strands too small to map separately from adjoining stands of assemblage 61 at a scale of 25 pixels. The map was printed at 1:100 000 scale and is available digitally at 25 m pi scale on licence (GIS manager, NSW National Parks and Wildlife Service).

Distribution, extent, depletion and reservation of floristic assemblages

Maps in the Appendix show the location of samples assigned to each floristic assemblage and the distribution of their map units excluding areas cleared before 1994 are shown on the vegetation map (inside back cover). Rainforests are scattered in small patches throughout the coastal and tableland ranges, but rarely occur in low relief parts of the hinterland and tableland (Fig. 7g). Mesic eucalypt forests are widespread on the tableland range, more scattered on the coast and hinterland and absent from the rainshadow areas of the lowland valleys and Monaro Tableland (Fig. 7a). Intermediate eucalypt forests occur mainly on the coastal ranges (Fig. 7b). Warm temperate dry grassy eucalypt forests occupy the lowland rainshadow valleys (Fig. 7f), while related forests occur in the hinterland (Fig. 7e). Cool temperate dry grassy forests and woodlands and treeless grasslands (Fig. 7d) occupy the low relief rainshadow areas of the Monaro Tableland. Dry shrubby eucalypt forests are widespread in the coastal region and hinterland, but become more scattered on the tableland range and they are very rare in the rainshadow areas of lowland valleys and the tableland (Fig. 7c). Heathlands and scrubs are restricted to small areas on exposed coastal and tableland sites or specialised habitats in the hinterland such as riparian zones or rocky outcrops (Fig. 7i). Wetlands are also restricted to small patches, either in estuaries, on floodplains or broad headwater valleys in the southern coast and hinterland, and the eastern edge of the Monaro Tableland (Fig. 7h).

The predicted pre-1750 extent of floristic assemblages varies from more than 40 000 ha (map units 13, 15, 19 and 24) to less than 100 ha (units 1, 5, 51, 65, 66 and 69). The latter include rainforests, scrub on rocky outcrops and estuarine wetlands (Table 11). Habitat loss due to vegetation clearing has affected floristic assemblages unevenly. By 1994 some floristic assemblages had been depleted by more than 90%, while others remain at close to their original extent (Table 11). The floristic assemblages most depleted by clearing are in the Bega and Towamba valleys (18, 19, 20, 21, 39 & 40), on the Monaro Tableland (22A, 22B, 23A, 23B, 24 & 59) and along the coastal strip (36 & 60). The remaining area of these units is largely on private or leasehold land (Table 11). Reservation status was also highly biased (Table 11, Fig. 8). Floristic assemblages typically inhabiting steep, infertile terrain (e.g. map units 25, 49, 50, W1–W6) had high proportional reservation, while those found in low relief, fertile terrain had very low proportional reservation (e.g. 20, 21, 22A, 22B, 60).

Map validation

Qualitative checking revealed a number of mapping anomalies generated by the first iteration of decision rules. For example, some stands of map unit 58 (Swamp Forest) had initially been mapped along contours in the south-western part of the region. Comments on the field data sheets and our recollections from the field indicated that this type of vegetation occurs on flats along drainage lines. The anomaly was rectified by replacing maximum temperature and elevation with topographic roughness and wetness index in the appropriate decision rule. Other identified anomalies were similarly rectified.

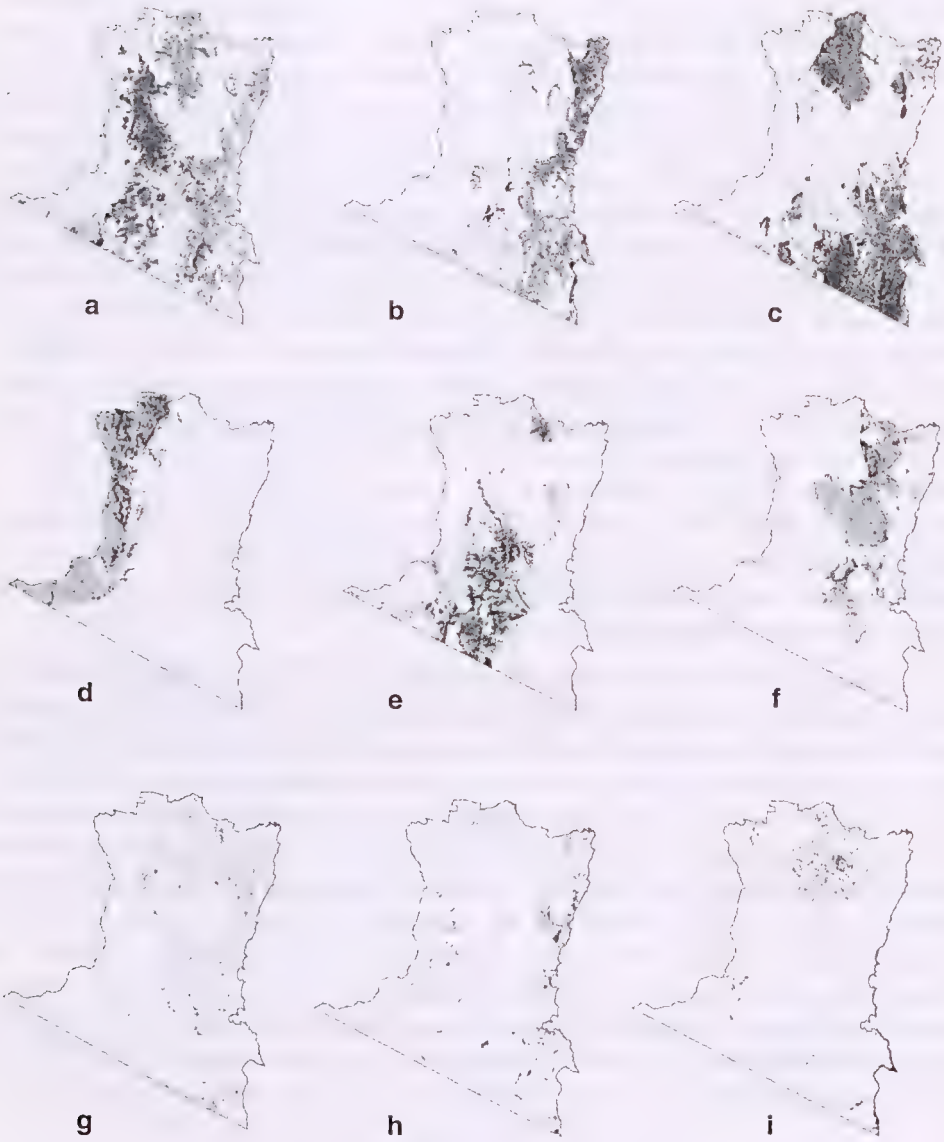

Fig. 7. Extant (black) and former (grey) distributions of a) mesic eucalypt forests (map units 9–17), b) intermediate dry forests (map units 2, 3, 32–34, 36, 37 and W6), c) dry shrubby forests (map units 25, 41–50, W1–W3 and W5), d) dry grassy tableland assemblages (map units 22–24 and W4), e) dry grassy hinterland forests (map units 26–31 and 35), f) dry grassy coastal valley forests (map units 18–21), g) rainforests (map units 1, 5–8), h) wetlands (map units 38–40, 57–60 and 63–70), and i) scrubs and heathlands (map units 4, 51–56, 61 and 62).

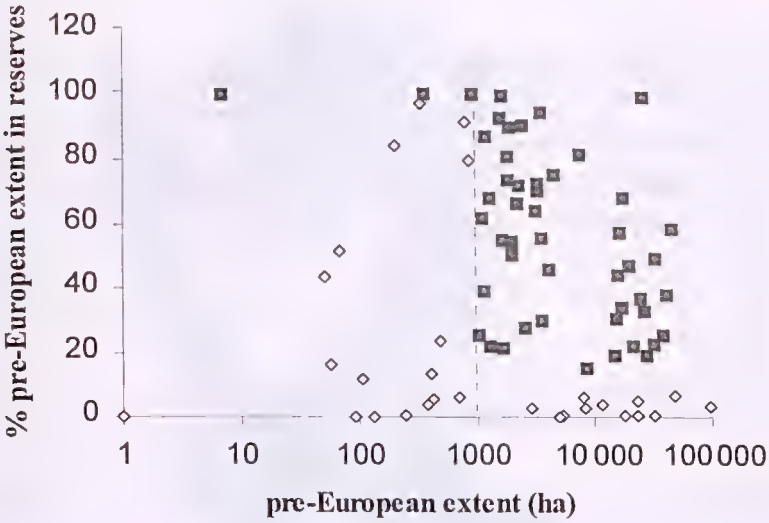

Fig. 8. Representation of map units in conservation reserves (Nature Reserves, National Parks and Flora Reserves). Broken line represents the JANIS (1996) threshold discriminating the general target for reservation of 15% of pre-european extent from the special target of 100% for rare units less than 1000 ha in pre-european extent. Open symbols show assemblages that do not meet relevant target, filled symbols show assemblages that do meet target.

Mean sampling density within a 5 km radius varied from less than 0.1 samples.km^{-2} extant native vegetation to more than 7 samples.km^{-2}. Sampling density was lowest (< 0.2 samples.km^{-2}) in: tableland remnants near Kybean and Craigie; inaccessable wilderness in the upper Brogo River catchment; and areas of State Forest south and north-east of Narrabarba, and in the upper Genoa River area adacent to the Victorian border (Fig. 9). The highest levels of sampling density (> 1 sample.km^{-2}) were in National Parks on the tableland range in the Coolangubra-Nalbaugh and upper Tantawangalo Creek areas, the Egan Peaks-Yowaka area west of Pambula; around Mt Waalimma near the Victorian border; and in privately owned remnant vegetation in the Bega valley (Fig. 9).

The 154 samples withheld from modelling for accuracy quantification represented map units 13, 14, 15, 31, 32, 33, 34, 37, 42, 46A, 46B, 47, 49, 53, 61, 62, W1 and W6. Overall map accuracy varied from 72% within 100 m to 96% within 1 km (Fig. 10). At the average spatial scale of planning units used in the Comprehensive Regional Assessment (100 ha forestry coupes and subcatchments), overall map accuracy was 93%. Thus, based on the 154 validation samples, there was a 93% chance that a planning unit selected to represent a particular map unit actually contained some of that map unit. Gains in accuracy increased at a decreasing rate with increasing neighbourhood size. The most accurately mapped assemblages included map units 35, 42, 53 and 61, while map unit 13 was the least accurately mapped. Many of the less widespread map units excluded from validation were modelled principally using aerial photograph interpreted spatial layers (e.g. rainforests, heaths, swamps). It was thus assumed that these units were mapped with reasonable reliability.

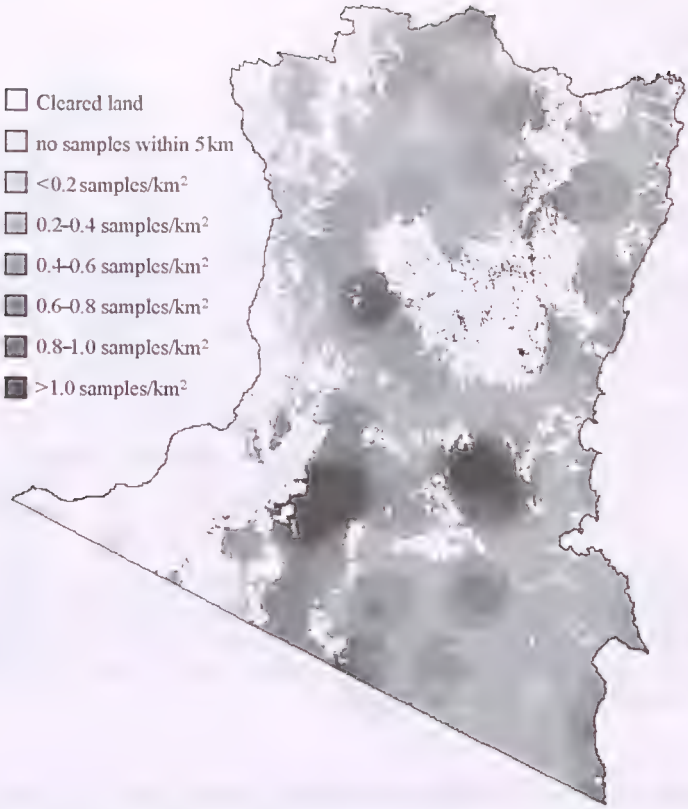

Fig. 9. Map reliability as represented by the mean number of samples per square kilometre of extant native vegetation within circular neighbourhoods of 5 km radius.

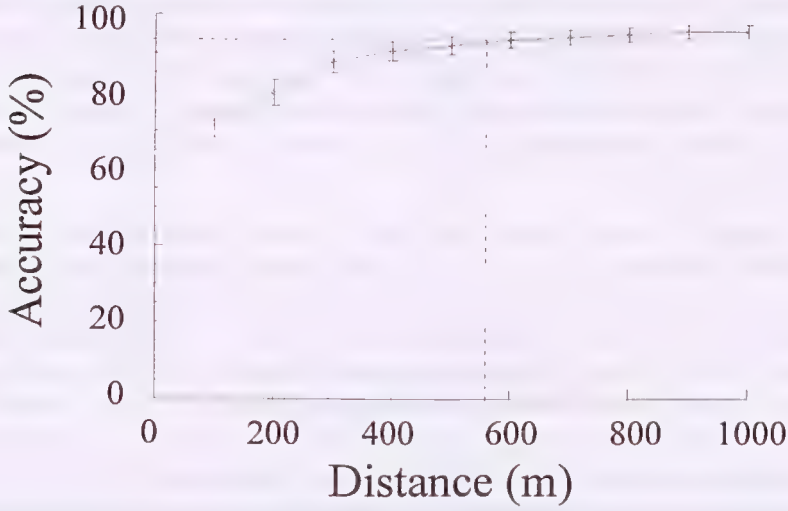

Fig. 10. Accuracy assessment of the vegetation map at varying spatial scales. Accuracy is the percentage of samples for which the floristic assemblage matched a mapped unit within varying distances of its location. Error bars are standard errors of the binomial distribution. Dotted line indicates the average spatial scale of planning units used in the Comprehensive Regional Assessment (100 ha).

Table 11. Pre-1750 extent of floristic map units, their depletion and representation on various land tenure classes as of 1st April 1999.

Floristic Assemblage	Pre1750 extent (ha)	Extant area 1994 (ha)	% depleted	National Parks & Nature Reserves (ha)	Flora Reserves (ha)	State Forest (ha)	State Forest plant-ation	Reserved Crown Land (ha)	Other Crown Land (ha)	Leased Crown Land (ha)	Private Land (ha)
1 Dry Rainforest	70	63	9	36	0	0	0	0	0	3	24
2 Myanba Dry Scrub Forest	334	334	0	323	0	0	0	0	0	0	10
3 Rocky Tops Dry Scrub Forest	1205	1205	0	1043	0	136	2	4	0	0	22
4 Acacia Scrub	3623	3585	1	3416	0	0	0	0	1	0	168
5 Bunga Head Rainforest	7	7	0	7	0	0	0	0	0	0	0
6 Coastal Warm Temperate RF	4160	4143	0	1910	169	1626	3	19	1	0	415
7 Hinterland Warm Temperate RF	1883	1878	0	1521	48	184	0	6	5	0	115
8 Cool Temperate Rainforest	874	844	3	696	20	94	0	0	0	1	35
9 High Mountain Wet Layered Forest	2267	1815	20	1489	124	131	0	0	8	0	63
10 Mountain Wet Layered Forest	20183	18091	10	9444	15	5138	32	148	21	245	3048
11 Tantawangalo Wet Shrub Forest	809	808	0	741	0	59	0	4	0	0	4
12 Mountain Wet Fern Forest	2322	2279	2	1666	22	508	8	12	0	1	64
13 Hinterland Wet Fern Forest	45986	43190	6	26677	555	8980	38	200	79	100	6562
14 Hinterland Wet Shrub Forest	27252	26169	4	8885	150	12860	0	364	74	17	3820
15 Mountain Wet Herb Forest	41575	30895	26	15612	560	10365	296	108	35	78	3841
16 Basalt Wet Herb Forest	14961	12263	18	3537	27	3100	149	104	39	295	5011
17 Flats Wet Herb Forest	3572	2949	17	1070	34	379	60	20	0	1	1385
18 Brogo Wet Vine Forest	8705	5046	42	1348	29	101	0	1	1	11	3555
19 Bega Wet Shrub Forest	48885	17959	63	3336	17	1026	133	37	31	37	13342

Table 11. cont.

Floristic Assemblage	Pre1750 extent (ha)	Extant area 1994 (ha)	% depleted	National Parks & Nature Reserves (ha)	Flora Reserves (ha)	State Forest (ha)	State Forest plant-ation	Reserved Crown Land (ha)	Other Crown Land (ha)	Leased Crown Land (ha)	Private Land (ha)
20 Bega Dry Grass Forest	32639	4429	86	275	0	20	25	27	3	12	4066
21 Candelo Dry Grass Forest	18015	1578	91	93	0	0	0	2	2	0	1481
22A Monaro Dry Grass Forest	11860	8222	31	527	0	17	0	88	5	643	6942
22B Numeralla Dry Shrub Woodland	5408	3611	33	1450	0	0	1	133	100	630	1298
23A Monaro Grassland	5096	311	94	0	0	0	0	0	0	1	310
23B Monaro Basalt Grass Woodland	23473	3395	86	109	0	82	234	107	0	32	2831
24 Subalpine Dry Shrub Forest	94924	26520	72	3589	8	1616	443	214	93	2546	18011
25 Sandstone Dry Shrub Forest	1140	821	28	697	28	95	0	0	0	0	0
26 Tableland Dry Shrub Forest	28011	16080	43	5424	284	6733	99	56	0	231	3252
27 Waalimma Dry Grass Forest	1324	1324	0	294	0	1031	0	0	0	0	0
28 Wog Wog Dry Grass Forest	1304	922	29	881	1	13	3	0	0	0	23
29 Nalbaugh Dry Grass Forest	2597	1937	25	711	2	875	78	3	0	12	256
30 Wallagaraugh Dry Grass Forest	1663	914	45	356	7	311	13	1	0	0	226
31 Hinterland Dry Grass Forest	33040	27700	16	16161	119	6275	281	113	0	50	4700
32 Coastal Foothills Dry Shrub Forest	24738	23614	5	9069	45	9123	0	729	147	25	4475
33 Coastal Range Dry Shrub Forest	16498	16336	1	9379	221	5614	19	15	32	5	1051
34 Coastal Gully Shrub Forest	17576	15289	13	5963	0	3913	0	201	109	46	5057
35 Escarpment Dry Grass Forest	38487	24423	37	9653	35	979	418	443	19	109	12768
36 Dune Dry Shrub Forest	1055	646	39	319	0	4	0	47	19	0	256
37 Lowland Gully Shrub Forest	15520	14685	5	4797	486	7699	0	81	21	6	1595

Floristic Assemblage	Pre1750 extent (ha)	Extant area 1994 (ha)	% depleted	National Parks & Nature Reserves (ha)	Flora Reserves (ha)	State Forest (ha)	State Forest plant-ation	Reserved Crown Land (ha)	Other Crown Land (ha)	Leased Crown Land (ha)	Private Land (ha)
38 Southern Riparian Scrub	490	441	10	116	168	42	9	0	0	0	106
39 Northern Riparian Scrub	693	447	35	44	0	2	6	0	2	2	393
40 Riverine Forest	249	197	21	1	0	1	0	0	0	0	195
41 Mountain Intermediate Shrub Forest	1878	1877	0	1376	196	243	0	3	0	6	54
42 Inland Intermediate Shrub Forest	21918	21429	2	4791	959	14952	1	11	22	2	692
43 Mountain Sandstone Shrub Forest	2497	2484	1	2249	17	63	0	0	0	0	154
44 Foothills Dry Shrub Forest	3337	3152	6	2322	28	689	67	0	0	0	45
45 Mountain Dry Shrub Forest	2040	1930	5	1023	71	464	17	0	0	1	354
46A Timbillica Dry Shrub Forest	22922	22797	1	1167	2345	18720	13	11	0	0	542
46B Lowland Dry Shrub Forest	16461	15428	6	7355	3	5165	8	447	100	0	2350
47 Eden Dry Shrub Forest	17892	17246	4	12145	250	3740	16	99	69	1	927
48 Mumbulla Dry Shrub Forest	4617	4576	1	3492	0	796	0	69	1	0	217
49 Coastal Dry Shrub Forest	32846	32240	2	7382	1063	20254	0	55	61	1	3423
50 Genoa Dry Shrub Forest	3697	3022	18	2037	37	737	11	0	0	1	200
51 Rhyolite Rock Scrub	51	51	0	22	19	7	0	0	0	0	3
52 Mountain Rock Scrub	202	202	0	170	17	9	1	0	0	0	6
53 Montane Heath	3248	3025	7	2391	0	3	19	60	10	121	420
54 Mt Nadgee Heath	371	371	0	371	0	0	0	0	0	0	0
55 Coastal Lowland Heath	1618	1582	2	1493	0	7	0	0	4	0	78
56 Hinterland Heath	385	385	0	16	68	286	0	0	0	0	15

Table 11. cont.

Floristic Assemblage	Pre1750 extent (ha)	Extant area 1994 (ha)	% depleted	National Parks & Nature Reserves (ha)	Flora Reserves (ha)	State Forest (ha)	State Forest plant-ation	Reserved Crown Land (ha)	Other Crown Land (ha)	Leased Crown Land (ha)	Private Land (ha)
57 Lowland Swamp	1662	1589	4	912	146	407	0	2	0	3	118
58 Swamp Forest	1190	1056	11	463	4	539	9	1	0	0	39
59 Sub-Alpine Bog	8188	1897	77	492	1	259	40	14	17	62	1013
60 Floodplain Wetlands	8537	2774	68	267	0	239	0	185	123	10	1951
61&62 Coastal Scrub & Beach Strand	2015	1358	33	1091	0	0	0	52	61	0	154
63 Estuarine Wetland Scrub	2970	956	68	123	0	15	0	55	21	3	738
64 Saltmarsh	411	295	28	62	0	4	0	33	49	15	133
65 River Mangrove	1	1	19	0	0	0	0	0	0	0	1
66 Grey Mangrove	92	60	35	13	0	1	0	1	0	0	45
67 Seagrass Meadow *(Halophila)*	108	108	-	13	0	3	0	0	0	0	15
68 Seagrass Meadow *(Posidonia)*	130	130	-	0	0	0	0	1	0	0	7
69 Seagrass Meadow *(Ruppia)*	56	56	-	10	0	2	0	0	0	0	20
70 Seagrass Meadow *(Zostera)*	423	423	-	24	0	5	0	4	1	0	74
W1 Wadbilliga Dry Shrub Forest	27347	27336	0	26913	0	65	0	0	109	39	211
W2 Wadbilliga Range Shrub Forest	933	933	0	933	0	0	0	0	0	0	0
W3 Wadbilliga Heath Forest	1683	1683	0	1671	0	0	0	0	0	2	10
W4 Kydra Flats Grass Forest	3386	3098	9	2434	0	106	0	48	51	108	350
W5 Wadbilliga Gorge Dry Forest	7938	7423	6	6446	0	3	0	0	6	0	968
W6 Wadbilliga River Valley Forest	1952	1947	0	1754	0	0	0	0	0	0	194
Total	809476	552284	32	246083	8398	156916	2554	4439	1550	5511	126295

Discussion

Biogeographic and environmental relationships of vegetation

The Eden region is centrally placed in Australia's unique eucalypt forest biome in a zone of climatic transition where subtropical and warm and cool temperate floras are juxtaposed (Beadle 1981, Keith & Sanders 1990). Subtropical elements of the regional flora are largely confined to a coastal strip extending north from Bega and represented on a continental scale by Nix's (1982) Torresian bioclimatic zone. The diminution of the subtropical flora with latitude is illustrated by numerous plant species, including many characteristic of rainforest habitats, reaching their southern limits of distribution in the Eden region (Keith 1990, Keith & Ashby 1992). Broad-scale latitudinal trends in species composition have been documented in both rainforests (Webb et al. 1984) and heathlands (Specht 1979). Turnover in eucalypt species composition occurs in relation to gradients of temperature and rainfall across south-east New South Wales (Austin et al. 1984).

The majority of the Eden region supports a temperate flora and is represented on a continental scale by Nix's (1982) Bassian bioclimatic zone, which becomes increasingly restricted to the tablelands further north. The temperate flora contains many plant taxa with southern Gondwanan origins (Keith & Sanders 1990). The cool temperate component of this flora is characterised by mesic elements strongly represented in floristic assemblages 8–17 and W4. Some widespread characteristic species include *Eucalyptus fastigata, E. obliqua, E. cypellocarpa, Bedfordia arborescens, Olearia argophylla, Blechnum nudum, Polystichum proliferum* and *Stellaria flaccida*. Their structural features include tall straight eucalypt dominants (except Cool Temperate Rainforest) and dense understories comprising various mixtures of ferns, mesophyllous shrubs and forbs. Subcanopies of small mesophyllous trees are essentially unique features of this group of assemblages. These mesic assemblages are widespread on elevated parts of the region that experience both high rainfall and cool temperatures (Fig. 7). Eight (map units 8–12, 15, 16 and W4) of these 11 mesic assemblages occur principally above 500 m elevation, while the two that are widespread below 400 m elevation (map units 13 and 14) are restricted to topographically sheltered sites in coastal and hinterland parts of the region.

A very different cool temperate flora inhabits elevated parts of the region that experience cool temperatures but low rainfall. This climatic regime typifies the Monaro Tableland, an extensive low-relief inclined plateau in a rainshadow that stretches from the escarpment range westward beyond the study area to the Australian alps (Costin 1954). The most widespread floristic assemblages here are dry grassy eucalypt forests and woodlands (map units 22–24, Fig. 7). Widespread characteristic species include *Eucalyptus pauciflora, E. dives, E. dalrympleana, E. viminalis, Poa sieberiana, Themeda australis* and *Asperula conferta*. Structurally these dry cool temperate assemblages comprise an open canopy of small eucalypts (except in Monaro Grassland) with an open or non-existent shrub stratum and continuous ground stratum dominated by grasses with interstitial herbs. Similar vegetation formations occupy elevated rainshadows of the Great Dividing Range as far north as

the New England Tableland and south at lower elevations in Victoria and the Tasmanian midlands (e.g. Fensham 1989). All of these regions have been exploited for their pastoral resources.

A predominantly dry warm temperate flora dominates the coast and hinterland. The driest parts of this zone are the large rainshadow valleys of the Bega and Towamba Rivers, which are dominated by dry grassy eucalypt forests (map units 18–21). Widespread characteristic species include *Eucalyptus tereticornis, E. baueriana, E. melliodora, Eragrostis leptostachya, Dichanthium sericeum, Themeda australis* and *Desmodium brachypodum*. The dominant eucalypts may form a tall but open canopy above an open stratum of smaller *Acacia* trees. The shrub stratum is variable, but most developed on sites with either higher rainfall or greater topographic shelter (map units 18 and 19). A continuous cover of grasses and interstitial herbs dominates the ground stratum. Distance from the coast and cold air drainage result in low winter temperatures, even though summer maxima may be high. Consequently, some elements of the dry cool temperate flora (e.g. *E. pauciflora, E. dives*) occur sporadically in the coastal rainshadow valleys (e.g. near Candelo and Wolumla). Similar rainshadow valleys are scattered to the north (e.g. Araluen valley, Cumberland Plain, Hunter valley), although their occurrence is limited further south, with the Gippsland Lakes district being the most physiographically similar valley. All of these regions have also been exploited for their pastoral resources.

Beyond the rainshadow valleys, the coast and hinterland are dominated by a variety of shrubby eucalypt forests, although mesic eucalypt forests (map units 13 and 14) and warm temperate rainforests (units 6 and 7) occupy the most sheltered parts of the landscape. Typical widespread species of the warm temperate shrubby eucalypt forests include *Eucalyptus sieberi, E. globoidea, Corymbia gummifera, Platysace lanceolata, Epacris impressa, Leucopogon lanceolatus, Pultenaea daphnoides, Lepidosperma laterale* and *Lomandra multiflora*. Although all these assemblages share a sclerophyllous shrub stratum, their structural characteristics are variable. The tallest of the shrubby eucalypt forests (map units 32– 34, 37, 41, 42 and W2) occupy open gullies and less exposed slopes on the coastal ranges and hinterland. They may also occupy elevated sites on coastal ranges or mountain slopes where rainfall is high relative to most of the coast and hinterland. *Eucalyptus obliqua* and *E. muelleriana* are frequently among the most abundant canopy species with *E. sieberi*, while the shrub stratum may be dominated by Asteraceous and Fabaceous genera such as *Ozothamnus, Cassinia, Acacia, Daviesia* and *Pultenaea*. Ridges and more exposed slopes, especially on quartz-rich, low fertility substrates, support shorter forests dominated by *E. sieberi*, either in pure stands or with *E. agglomerata, E. consideniana, E. globoidea* or *C. gummifera*. Their prominent, open shrub strata are dominated by scleromorphs such as *Lomatia ilicifolia, Epacris impressa, Leucopogon lanceolatus, Podolobium ilicifolium* and *Platysace lanceolata* and a sparse groundcover of scleromorphic graminoids (map units 36, 43–50, W1, W3 and W5). Lower relief terrain in the hinterland supports dry eucalypt forest assemblages in which a grassy ground stratum may attain greater cover than the shrub strata (map units 25–31 and 35). Characteristic species here include *E. globoidea, E. maidenii, E. angophoroides, Poa meionectes, Senecio* sp. E and *Hibbertia obtusifolia*.

Variation in topography and soils superimposes local vegetation patterns on coarse scale climatic trends. The nutrient and moisture statuses of soils interact to produce complex environmental relationships with vegetation in the Eden region (Keith & Sanders 1990). Soil nutrient status varies between lithological substrates and across the catenary profile (Kelly & Turner 1978, Turner et al. 1978). Soil moisture varies with regional precipitation patterns, topographic exposure and terrain flows (Keith & Sanders 1990). In general, sheltered mesic sites with relatively high soil fertility support rainforest. Mesic eucalypt forests are found on moister, more fertile soils than sclerophyllous eucalypt forests, while sclerophyllous forests with grassy understories are generally associated with more fertile soils than those with shrub-dominated understories (Keith & Sanders 1990). These general relationships are well known in other parts of eastern Australia (e.g. Beadle 1954, Costin 1954, Keith 1994, Le Brocque & Buckney 1997).

Many of the region's floristic assemblages are restricted to localised habitats defined by specialised topographic and soil conditions. These include: rainforests restricted to relatively fertile soils in very sheltered gullies (map units 5–8) or upper slopes (map unit 1); riparian scrubs and forest restricted to narrow bands of river alluvium (map units 38–40); scrubs restricted to skeletal soils on rocky outcrops (map units 51 and 52); heathlands restricted to exposed slopes on quartz-rich low-fertility soils (map units 53–56); freshwater swamps restricted to periodically waterlogged soils (map units 57–60); scrub and grassland restricted to maritime sands (map units 61 and 62); and estuarine wetlands restricted to inter-tidal and sub-tidal zones (map units 63–70). Some vegetation patterns are related to the distribution of parent materials. For example, two of the mesic eucalypt forest assemblages (map units 13 and 14) are found in similar climatic and topographic habitats, but one is found primarily on granitoid substrates and the other is found primarily on metasedimentary substrates. Some parent materials support distinctive groups of floristic assemblages (e.g. map units 16, 22A and 22B are primarily restricted to basalt), while several assemblages have high fidelity to one type of parent material (e.g. map units 4, 51, 62).

Recurring landscape fires influence spatial patterns in vegetation through time. It seems likely that fires are at least partly responsible for the restriction of rainforest and related scrubs (map units 1–8) to small patches in the landscape (Floyd 1990). General models of the dynamics of temperate wet sclerophyll forests suggest several successional pathways are possible under alternative fire regimes, with fire exclusion eventually leading to rainforest development and high frequency fire regimes leading to the elimination of eucalypts and dominance of shrubs (Ashton 1981, Noble & Slatyer 1981). Models and empirical studies of heathland and upland swamps similarly suggest elimination of certain functional groups of plant species under sustained high and low frequency fire regimes, respectively (Keith 1991, Keith & Bradstock 1994, Bradstock et al. 1997). Shifts in floristic composition including local extinctions may occur in response to fire regimes. However, the spatial patterns in composition attributable to disturbance history are generally smaller than those attributable to physical environmental factors such as soil texture and moisture, at least in the short term (Bradstock et al. 1997).

Conservation

Eucalypt forests are physiognomically, structurally and floristically unique to Australia (Beadle 1981, Ovington 1983). Other temperate forested regions of the world support rainforests, deciduous forests or coniferous forests (Ovington 1983). The Eden region has a diverse range of eucalypt forests and is placed centrally in the east Australian eucalypt forest belt that spans 15° latitude from south-east Queensland to south-east Tasmania. Alpha species richness values for mesic and dry grassy eucalypt forests in Eden are among the highest in the world recorded for temperate forests (e.g. Whittaker & Woodwell 1969, Glen-Lewin 1975, Peet 1978, Kirkpatrick 1984, Cawe & McKenzie 1989, Wardell-Johnson et al. 1989, Fensham 1989). Sclerophyllous shrubby forests and heathlands exhibit intermediate species richness in the Eden region compared with those elsewhere (Whittaker 1979, Gimingham et al. 1979, George et al. 1979, Rice & Westoby 1983, Cowling 1983, Keith 1994). At landscape scale, the Eden region has a large native flora relative to forested regions of similar size at similar latitudes, but the flora is small compared to southern mediterranean regions and some eucalypt forests regions further north (Keith et al. 1999).

Threatening Processes

A range of threatening processes influence the conservation status of vegetation in the region (Appendix). These include habitat loss, certain disturbance regimes, overgrazing, nutrification, habitat degradation due to human misuse and feral animal activity. Continuing habitat loss due to clearing affects vegetation close to developing coastal resort centres, dry grassy eucalypt forests in agricultural zones and other forest assemblages on the margins of these zones. Clearing and subsequent land use change usually results in irreversible loss of native vegetation and is almost entirely restricted to private tenures. Small-scale clearing occurs on public land for the construction of public facilities and access. Although the rate of clearing has slowed substantially since the early 20th century, losses are spread unevenly (Table 11) and the continuing loss of small vegetation remnants in the region is reducing some types of vegetation to very small proportions of their original extent. Some regrowth of native vegetation has occurred in marginal agricultural districts, but there are few examples where such vegetation has attained a structure and composition that closely resembles uncleared vegetation. In concert with feral predators, continuing habitat loss is correlated with several regional extinctions of fauna (Lunney & Leary 1988).

Disturbance regimes involving fires and logging may threaten populations of certain species depending on how the timing and type of disturbance events interact with their life history (Whelan 1995, Williams et al. 1995, Keith 1996). Logging is not carried out in conservation reserves, but fires may occur across all land tenures. Rainforests are especially susceptible to intense wildfires which may result in major changes in structure and composition (Ashton & Frankenberg 1976, Floyd 1990) or elimination, as apparently occurred on Mt Darragh in 1942 (F. Carey pers. comm.). These effects may be exacerbated under higher fire frequency. In eucalypt forests, woodlands, scrubs and heathlands high frequency disturbance regimes may cause declines and local extinctions of some woody plant species. This effect is most conspicuous in species

that depend on seed for regeneration (obligate seeders), but declines in resprouters may occur if high frequencies are sustained over several disturbance cycles (Keith 1996, Keith & Tozer 1997). Declines or elimination of certain eucalypts (particularly ashes) may occur if intervals between successive disturbances that kill standing trees are less than 20 years (Ashton 1981). Interactions between species, such as competitive effects of dense vegetative regrowth on seedling recruitment may exacerbate these effects. The existence of large stands of *Acacia dealbata* with sparse emergents of *Eucalyptus fastigata* and *E. nitens* near Nunnock River and Wog Wog Mountain lend tacit support for such fire effects within the region. Introduction of logging and associated soil disturbance and burning practices into the disturbance regime of production forests may cause additional effects (e.g. Dickinson & Kirkpatrick 1987). These disturbance regimes may result in increased relative abundance of fecund species such as *Eucalyptus sieberi* that establish rapidly and in greater numbers in exposed conditions relative to their competitors (Bridges 1983). Conversely, comparative studies on *Dicksonia antarctica* and associated epiphytes (Ough & Ross 1992) have shown that populations of other species may decline if plants are killed by logging treatments and require undisturbed conditions for establishment. Logging may also exacerbate the competitve elimination of some slower growing woody species, as their seedlings are deprived of light and perhaps other resources by fast-growing thicket-forming species such as some fern species and *Senecio linearifolius*. Although the densities of these opportunists may eventually decline, they may be replaced by taller, more persistent dense canopies such as *Bedfordia arborescens*. The role of these interactions in the failure of eucalypt regeneration in logged areas of mesic forest warrants further investigation.

Domestic cattle, sheep, feral and domestic goats and rabbits graze native vegetation, as do native herbivores. The impacts are likely to be greatest in remnants of grassland and dry grassy eucalypt forests and woodlands in and around the main pastoral districts (Bega and Towamba valleys and the Monaro Tableland). Grazing affects native plant species differentially according to interactions between their palatability, growth form and regeneration capacity. One of the most palatable native pasture species, *Themeda australis*, proliferates when grazing is excluded, particularly in response to summer rain, but may be eliminated under continued heavy grazing regimes (Vickery 1961). Forbs with erect growth forms are more prone to declines under grazing than those with rosette or prostrate growth forms, apparently because of the greater exposure of their buds to herbivory (McIntyre et al. 1995). However, grazing is one of several mechanisms that create gaps in grass canopies, which are an important requisite for seedling establishment in many species (Lunt 1991, Morgan 1997). These species may vary in the extent to which they exploit different kinds of gaps. In some cases this may provide opportunities for establishment of alien plant species, particularly if these are less palatable than native competitors. Nutrient enrichment, either through animal dung or direct pasture improvement may confer further advantages on alien species. Heavy grazing may exacerbate rates of soil erosion by increasing the exposure of soils to rainsplash and runoff as well as wind (Costin 1954). Such effects may be particularly evident after prolonged drought when regrowth capacity is diminished.

Nutrification may be associated with drift and runoff from pasture improvement or with more localised urban and rural developments. The impacts are usually expressed in the replacement of some native plant species with mesophyllous herbs, grasses and shrubs, many of which are introduced (e.g. Clements 1983). Scleromorphic shrubs are the most susceptible species to nutrification, either through direct toxicity effects or because they are eliminated by competitors with superior growth responses. Competitive relationships under varying nutrient regimes may also result in shifts in the relative abundance of native species. Groves et al. (1973), for example, found that *Poa labillardieri* showed a greater response to increased soil phosphorus and nitrogen than *Themeda australis*. The habitats most susceptible to nutrification include vegetation remnants in and around urban and rural developments and improved pastures, as well as riparian habitats and wetlands exposed to water runoff from these areas. Benson (1994), for example, observed higher levels of weed invasion along drainage lines in a *Poa labillardieri* tall tussock assemblage than in other Monaro grassland habitats.

Dumping and vandalism causes localised but significant habitat degradation near inhabited areas such as urban and rural centres and popular recreation sites. These threats are most significant for populations of rare plant species or floristic assemblages whose occurrences are concentrated in areas close to habitation (e.g. map units 36 and 61). Feral pigs are also associated with localised habitat degradation. Their intensive foraging activities cause major soil disturbance and varying levels of weed invasion, particularly in topographic flats in the south-west of the region. These sites support restricted floristic assemblages (map units 17, 30 and 58) and are likely to be important habitat resources for some native fauna. On parts of the Monaro Tableland, trampling by stock may have similar impacts on the soft organic soils of subalpine bogs (map unit 59).

Reservation and management

Management of conservation reserves is an important means of mitigating processes that threaten biodiversity. The reservation status of floristic assemblages was highly biased (Table 11, Fig. 8). Assemblages typically inhabiting steep, infertile terrain (e.g. map units 25, 41, 43, 47, 50, W1–W6) have more than two-thirds of their original extent represented in conservation reserves (Nature Reserves, National Parks and Flora Reserves). In contrast, assemblages found in low relief, fertile terrain have very low proportional reservation (e.g. Map Units 18, 19, 20, 21, 23A, 23B and 60). This kind of reservation bias has been demonstrated in other regions of New South Wales (Braithwaite et al. 1993, Pressey et al. 1996) and is apparently a world-wide phenomenon.

Many floristic assemblages have a relatively high proportion of their predicted pre-European occurrence represented in reserves. However, for assemblages with naturally restricted or highly depleted distributions, these proportions may amount to small areas and complete representation is considered a desireable goal for the conservation of biota within these units (JANIS 1996). Although a full appraisal of floristic assemblages in relation to criteria for a comprehensive, adequate and representative reserve system (JANIS 1996) is beyond the scope of this paper, two of

the eight biodiversity conservation criteria are represented in Fig. 8. These criteria require that at least 15% of the pre-European extent of ecosystems be represented in reserves and that 100% of rare ecosystems (i.e. current area < 1000 ha) be represented in reserves. Nearly two-thirds of the map units currently meet these targets (Fig. 8). Most of those that do not are rare and some are below high tide mark, although a number of widespread assemblages (map units 18–24 and 60) have very low proportions (0–10%) of their distribution represented in reserves (Table 11). The poorly reserved assemblages are among the most species-rich in the region (Table 7), the most depleted by past clearing (Table 11) and the most threatened by continuing processes (Appendix). These features suggest that the conservation of map units 18–24 and 60 should be a very high priority. However, their fragmented distribution largely on freehold and leasehold lands and the degraded state of many stands impose substantial challenges for effective conservation. In some cases (e.g. map units 20, 21, 23A, 23B, 60), levels of depletion are so great that JANIS (1996) targets are unattainable unless an extensive restoration of cleared areas currently in production is implemented.

Acquisition of private lands for inclusion in the public reserve network will be limited by cost, but a high priority must be given to the few opportunities to formally reserve the most threatened assemblages. Although some significant unprotected stands of threatened assemblages remain adjacent to existing reserves, these stands are often transitional and do not represent the full range of variation within the respective units. Complementary off-reserve conservation measures are essential if loss and degradation of these vegetation types is to be mitigated. These measures include: community conservation projects; Voluntary Conservation Agreements (legally binding agreements between landholders and the state government to protect native habitat); private purchase and management of land for conservation; implementation of a regional vegetation management plan under the NSW Native Vegetation Management Act (1996); and declaration of critical habitat for threatened species and ecological communities under the NSW Threatened Species Conservation Act (1995). The last two mechanisms stem from recent legislation and are yet to be implemented in the Eden region. However, there has been evidence of progress on other measures since 1990. Recent examples include: the implementation of fauna and flora surveys in the Bega valley (Whelan & Hibberd 1992, Keith 1995); the operation of a vegetation management advisory service for farmers during 1995–1997 (J. Miles, pers. comm.); implementation of two Voluntary Conservation Agreements to protect stands of map units 19 and 21, respectively; and the purchase and management of a land parcel containing stands of map units 1 and 18 by the Bush Heritage Fund in 1996.

While protection from further habitat loss is a principal concern on private land, public land is largely exempt from clearing activities. Here, management of the disturbance regime is a major factor mediating the persistence of native plants and animals. On the public land estate most of the area outside reserves is managed for wood production. Within production forest there is a system of management zones that provide varying levels of protection from logging. In some of these zones (unproductive forest, scenic protection, flora protection, wildlife corridors and filter strips) logging is excluded or regulated at reduced intensity. Outside special

management zones, protocols exist for the protection of certain habitats. Several naturally restricted floristic assemblages including some widely scattered in small stands are dependent on these measures to supplement low levels of representation in formal reserves (e.g. map units 17, 27, 30, 38 and 56), although in some cases the contribution is small. Within reserves, conservation is implemented primarily through the management of fire and visitor access, as well as rehabilitation works targeted at degraded locations.

Field identification of floristic assemblages

Floristic assemblages may be identified in the field by the co-occurrence of positive diagnostic species listed in the descriptions (Appendix). Positive diagnostic species are those that have high fidelity to a particular assemblage, i.e. high frequency and abundance relative to occurrences elsewhere (Table 4). Diagnostic species may be common or uncommon within their respective assemblages, but are always less common elsewhere. Examples include *Eucalyptus fraxinoides* and *E. ovata*, positive diagnostics for map units 41 and 58, respectively (Appendix). A species may be quite common in a particular assemblage, but may not be diagnostic of that unit if it is at least as common in several other units. These relatively ubiquitous species (e.g. *Eucalyptus sieberi*, *E. cypellocarpa*, Appendix) are less informative about the identity of a floristic assemblage at a given site.

The greater the number of diagnostic species identified in a particular stand, the more reliably a particular stand may be attributed to one of the floristic assemblages. The likelihood of membership of a stand to any given assemblage could be assessed statistically by using species frequency values to calculate the probability of finding a given combination of species in that assemblage. The probabilities of membership to alternative assemblages could thus be compared. If structural and habitat characteristics and stand location fall within the ranges specified for a particular assemblage (Appendix), this may be further evidence in support of a particular identification. Conversely, the presence of negative diagnostics and mismatches of other species, structural characteristics, habitat and distribution may be used to eliminate other possibilities from contention. Depending on available diagnostic species, definitive identification of vegetation at a given site may sometimes require sampling of full floristic composition and analysis with procedures such as those listed in Table 3. Although keys to floristic assemblages could be constructed (e.g. Outhred et al. 1985), we considered these to be inappropriate tools for field identification because they fail to consider variability within and between assemblages.

The continuous nature of variability in vegetation (Austin 1987) means that there will often be difficulty in assigning stands to classes, irrespective of how classes are defined. Furthermore, the classification and map of 79 vegetation units is a conservative representation of vegetation diversity for a coastal region of this size. Finer-scale analysis and recognition of more units at local scales could resolve some of the variability within units, particularly eucalypt forest assemblages. A finer-scale analysis will often be appropriate for assessments, planning and management of vegetation in local areas.

Map Accuracy

A range of factors is likely to influence the accuracy of the vegetation map. These include the comprehensiveness and evenness of sampling, characteristics of the vegetation classification, the accuracy of spatial data layers and the structure of the spatial model.

The comprehensiveness and evenness of sampling could be improved with additional sampling targeted at gaps (Table 1, Fig. 3, Fig. 9). The use of additional data from other surveys resulted in some areas being sampled at higher intensity than most other parts of the region. It may be expected that these areas are the most reliably mapped parts of the region (Fig. 9). Our recent sampling targeted at hitherto poorly surveyed areas (the Bega valley, Wallagaraugh catchment, Nungatta-upper Genoa area, Monaro Tableland and Numeralla area) would have improved map reliability and accuracy in those parts of the region. The least intensively sampled areas remaining include the dissected wilderness of the upper Brogo River (Wadbilliga National Park), parts of Nadgee, East Boyd and western Bondi State Forests, parts of the Monaro Tableland and a small part of the upper Towamba valley. However, notwithstanding possible refinements, the Eden region is now one of the most comprehensively surveyed regions in Australia and priorities for vegetation survey should lie elsewhere.

The characteristics of vegetation classifications should be driven largely by their purpose. Alternative vegetation classifications are possible, but it remains to be seen how different methods of classification and mapping affect the performance of alternative vegetation maps as surrogates for biodiversity. Nevertheless, the integration of quantitative field samples into the methodologies of both classification and mapping, and the relative stability of the classification since the earlier analysis by Keith & Sanders (1990) despite the inclusion of four times as many samples, suggest that the current classification and map are a robust representation of vegetation diversity in the region.

Inaccuracy in the spatial data layers may be responsible for some errors in vegetation mapping. During field work a number of small unmapped outcrops of various geological substrates (mainly basalt and metasediments) were discovered. While these were corrected on the digital substrate map before its use in modelling, other errors may await detection. Derived topographic variables such as slope, aspect, horizon azimuths (used in calculating radiation index) and wetness index are likely to deviate from field values more than raw altitude values because of their sensitivity to fine-scale topographic features. Climatic surfaces are possibly the least reliable of the spatial variables because of the sparse and uneven distribution of weather stations to calibrate predictions. Predicted mean temperatures and precipitation values are also sensitive to variation in observation periods between stations. Local climatic phenomena such as frost hollows may well have been under-represented in the climatic surfaces. We attempted to minimise these sources of error by using values from the spatial data layers to develop environmental relationships for mapping, rather than values measured or calculated from the field.

A wide range of models could be developed to provide an equally good fit to the sample data, but these may perform differently when evaluated against independent data. Procedures such as generalised linear models and generalised additive models have proved useful in the construction of distributional models for individual species (e.g. Austin et al. 1984, CSIRO 1996, Ferrier & Watson 1997, Elith et al. 1998). We chose a decision tree model structure because, although these may return slightly less accurate predictions from quantitative data, they have flexibility allowing the incorporation of qualitative expert knowledge into the mapping process. Arguably, alternative modelling approaches may have yielded a product of similar accuracy. Within a decision tree framework, many alternative structures offering a reasonable fit to the data are possible. With more time and more iterations in map checking, it may be possible to build a map that returns greater accuracy when evaluated against independent data.

The three approaches to map validation employed here (qualitative checking, description of map reliability and accuracy quantification) offer an overall measure of potential limitations discussed above. Qualitative checking is essential to correct the most simple and conspicuous inaccuracies that may arise in mapping. A description of map reliability alerts users to those areas subject to least survey effort, as well as providing some guidance for future sampling work. Accuracy quantification gives a minimal estimate of the likelihood that planning units of a given size actually contain a map unit that they may be selected to represent for some natural resource planning purpose. Validation is a much neglected component of mapping and is currently the subject of further research.

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Appendix: Descriptive profiles of floristic assemblages.

Each profile includes data tables summarising floristic composition, vegetation structure and physical habitat, respectively. Floristic data are the frequency and cover-abundance (median with interquartile range in parentheses) of each species in samples of the map unit being described (target unit) and its frequency and abundance in all other samples (residual). Residual abundance statistics exclude zero values. Fidelity classes are defined in Table 4. Structural tables summarise the frequency of occurrence, height (in metres) and percentage projective cover of foliage and branches for each of four strata. Data are means with standard errors. Habitat tables summarise mean and interquartile range of predicted annual rainfall, altitude, field slope, and frequency of samples among substrate types and among terrain classes defined by slope and aspect (see Table 2).

Map Unit 1 Dry Rainforest

Dry rainforest is dominated by *Ficus rubiginosa* with occasional *Pittosporum undulatum* and *Brachychiton populneus*. The dense canopy is c. 10 m tall with occasional emergent eucalypts to 23 m. The sparse shrub stratum includes *Alectryon subcinereus, Notelaea venosa* and *Hymenanthera dentatum*. *Dendrocnide excelsa* and *Deeringia amaranthoides* may be locally common in the northern part of the range. The groundcover comprises scattered patches of erect herbs *Plectranthus graveolens and Sigesbeckia orientalis* with the fern *Pellaea falcata* var. *falcata* and grass *Oplismenus imbecillis* among rocks. Dry Rainforest is restricted to small patches generally less than 10 ha, usually on steep upper granite slopes or heads of gullies facing north at 200–400 m elevation. These patches occur between Cobargo and Bega, south of Candelo and in the upper Towamba valley. Generally these are fragmented landscapes on hilly fringes of grazing districts, although significant stands occur from Reedy Creek to Mt Pericoe in Coolangubra National Park. Dry Rainforest is likely to be highly sensitive to fire because the some of the dominant trees may be killed when burnt. Re-establishment relies upon seed dispersed by birds from unburnt sites. The understorey may be adversely affected by grazing (cattle, sheep and rabbits) in rural districts. Some of these stands may also be affected by small-scale clearing. This assemblage appears to be unique to the region, since *F. rubiginosa* reaches its southern limit here (Keith et al. 1999) and similarly restricted dry rainforests further north differ compositionally, particularly in the dominance of *Backhousia myrtifolia* (Austin 1978, Helman 1983). In East Gippsland, Woodgate et al. (1994) described a dry rainforest assemblage (Ecological Vegetation Class 34) dominated by *P. undulatum* with *Acmena smithii* and similar understorey elements to those recorded in Eden. Only 11 ha of this unit was mapped in the East Gippsland region.

Species richness: 28 ± 5 (0.04 ha)
Extant area: 63 ha
Proportion cleared: 9% (probably an underestimate)
Number of samples: 6

Table 1a. Diagnostic plant species of Map Unit 1.

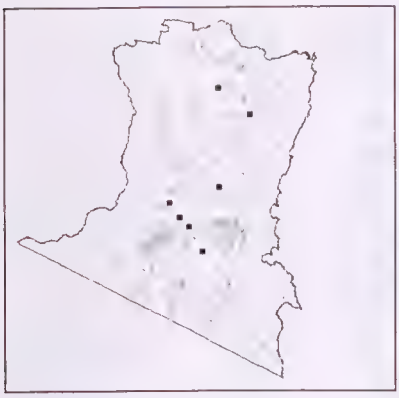
Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Brachychiton populneus subsp. *populneus*	0.833	2(1–3)	0.02	1(1–1)	positive
Celastrus australis	0.833	3(2–3)	0.008	1(1–1)	positive
Ficus rubiginosa	1	5.5(5–6)	0.005	1.5(1–4)	positive
Geitonoplesium cymosum	1	2(2–2)	0.106	1(1–1)	positive
Notelaea venosa	0.5	3(1–3)	0.112	1(1–2)	positive
Pellaea falcata var. *falcata*	1	2(2–3)	0.094	1(1–2)	positive
Pittosporum undulatum	0.833	3(2–3)	0.089	1(1–2)	positive
Plectranthus graveolens	0.5	2(1–3)	0.009	1(1–2)	positive
Sigesbeckia orientalis	0.5	2(1–2)	0.076	1(1–2)	positive
Solanum aviculare	0.167	2(2–2)	0	0(0–0)	positive
Alectryon subcinereus	0.667	1(1–3)	0.005	1(1–2)	frequent
Asplenium flabellifolium	0.833	1(1–2)	0.119	1(1–2)	frequent
Clematis glycinoides	0.667	1.5(1–3)	0.113	1(1–2)	frequent
Dichondra repens	0.833	1(1–1)	0.282	2(1–2)	frequent
Hymenanthera dentata	1	1(1–2)	0.066	1(1–2)	frequent
Oplismenus imbecillis	0.667	1.5(1–2)	0.106	2(1–2)	frequent
Urtica incisa	0.667	1.5(1–2)	0.067	1(1–2)	frequent
Eucalyptus polyanthemos subsp. *vestita*	0.167	3(3–3)	0.012	2(2–3)	uninformative
Eucalyptus sieberi	0.167	1(1–1)	0.283	3(2–4)	uninformative
Eucalyptus tereticornis	0.333	2(1–3)	0.046	3(1–3)	uninformative
Lomandra longifolia	0	0(0–0)	0.551	2(1–2)	negative
Poa meionectes	0	0(0–0)	0.541	2(1–3)	negative
Pteridium esculentum	0	0(0–0)	0.579	2(1–3)	negative

Table 1b. Vegetation structure of Map Unit 1. Frequency is the proportion of samples in which strata were present. Height and cover data are means with standard errors in parentheses (n=6).

Stratum	Frequency (%)	Height (m)	Cover (%)
Tree	50	23.0(2.4)	6(2)
Small tree	100	10.8(0.7)	80(5)
Shrub	100	1.7(0.3)	16(6)
Ground cover	100	0.3(0.0)	8(2)

Table 1c. Habitat characteristics of Map Unit 1. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5° and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		881	856–915	7
Altitude (m)		283	230–335	7
Slope (degrees)		34	31–37	7
Terrain class				
North	57			4
Intermediate	29			2
South	14			1
Flat	0			0
Parent material				
Devonian granitoids	71			5
Devonian high quartz sedimentaries	14			1
Ordovician high quartz sedimentaries	14			1



Map 1. Distribution of samples of Dry Rainforest (Map Unit 1) shown by large black squares. Samples of other map units shown as small grey points.

Plate 1. Dry Rainforest (Map Unit 1) dominated by *Ficus rubiginosa* and *Pittosporum undulatum* on the edge of paddocks near Verona, west of Cobargo.

Map Unit 2: Myanba Dry Scrub Forest

Myanba Dry Scrub Forest has an open stratum of *Eucalyptus bosistoana* and other eucalypts over a scrub stratum of *Ficus rubiginosa, Acacia falciformis, Cassinia* spp. and a range of other large shrub species. The understorey comprises a patchy cover of orchids *Dendrobium* spp., ferns *Asplenium* spp., *Pellaea falcata* and forbs *Stellaria flaccida* and *Urtica incisa* on and amongst rocks. Myanba Dry Scrub Forest is restricted to the steep dry rocky granite slopes of Myanba Creek gorge and the adjacent escarpment and appears to be unique to the region. This assemblage is entirely represented within Coolangubra National Park. Intense fires may reduce diversity, at least temporarily by eliminating figs and lithophytic orchids. Frequent low intensity fires could have a similar effect.

Species richness: 32 ± 3 (0.04 ha)

Extant area: 334 ha

Proportion cleared: 0%

Number of samples: 5

Table 2a. Diagnostic plant species of Map Unit 2.

Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Asplenium trichomanes subsp. *quadrivalens*	0.2	2(2–2)	0	0(0–0)	positive
Bulbine bulbosa	0.2	1(1–1)	0	0(0–0)	positive
Acacia falciformis	0.8	1(1–1)	0.188	2(1–3)	frequent
Asplenium flabellifolium	0.8	1(1–2)	0.119	1(1–2)	frequent
Cassinia aculeata	0.8	1(1–1)	0.161	1(1–2)	frequent
Cassinia trinerva	0.6	1(1–1)	0.082	1(1–3)	frequent
Dendrobium speciosum	0.6	1(1–2)	0.016	1(1–2)	frequent
Einadia nutans	0.8	1(1–1)	0.018	1(1–1)	frequent
Eucalyptus bosistoana	0.8	1(1–1)	0.05	2(1–3)	frequent
Ficus rubiginosa	0.6	1(1–3)	0.007	5(2–6)	frequent
Hymenanthera dentata	0.6	1(1–1)	0.068	1(1–2)	frequent

Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Lepidosperma laterale	0.6	1(1–1)	0.344	1(1–2)	frequent
Notelaea venosa	0.6	1(1–1)	0.112	1(1–2)	frequent
Pandorea pandorana	0.8	1(1–2)	0.119	1(1–1)	frequent
Pellaea falcata var. *falcata*	0.8	1(1–1)	0.095	1(1–2)	frequent
Pimelea axiflora	0.8	1(1–2)	0.117	1(1–2)	frequent
Solanum pungentium	0.6	1(1–1)	0.061	1(1–1)	frequent
Stellaria flaccida	0.6	1(1–2)	0.21	1(1–2)	frequent
Thonandia longifolia	0.6	1(1–2)	0.074	1(1–2)	frequent
Urtica incisa	0.8	1(1–1)	0.067	1(1–2)	frequent
Eucalyptus cypellocarpa	0.2	1(1–1)	0.314	3(2–3)	uninformative
Eucalyptus elata	0.2	1(1–1)	0.113	3(2–3)	uninformative
Eucalyptus obliqua	0.2	1(1–1)	0.19	3(2–4)	uninformative
Eucalyptus polyanthemos subsp. *vestita*	0.2	1(1–1)	0.012	2.5(2–3)	uninformative
Eucalyptus smithii	0.2	1(1–1)	0.045	2(1–3)	uninformative
Lomandra longifolia	0	0(1–0)	0.551	2(1–2)	negative
Poa meionectes	0.2	1(1–1)	0.54	2(1–3)	negative
Pteridium esculentum	0	0(1–0)	0.579	2(1–3)	negative

Table 2b. Habitat characteristics of Map Unit 2. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5° and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean Range	Interquartile	n
Annual rain (mm)		910	898–928	5
Altitude (m)		532	500–550	5
Slope (degrees)		45	45–45	1
Terrain class				
North	100			1
Intermediate	0			0
South	0			0
Flat	0			0
Parent material				
Devonian granitoids	100			5

Map 2. Distribution of samples of Myanba Dry Scrub Forest (Map Unit 2) shown by large black squares. Samples of other map units shown as small grey points.

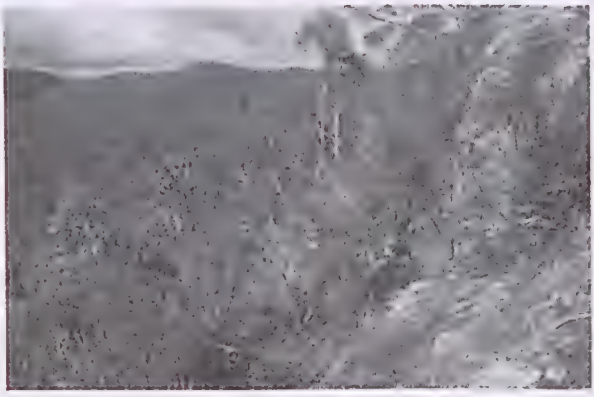


Plate 2. Myanba Dry Scrub Forest (Map Unit 2) with *Beyeria lasiocarpa, Dodonaea viscosa, Ficus rubiginosa* and *Pittosporum undulatum* amongst granitoid outcrops in Myanba Creek gorge, Coolangubra section of South East Forests National Park.

Map Unit 3: Rocky Tops Dry Scrub Forest

Rocky Tops Dry Scrub Forest is dominated by *Eucalyptus smithii* and other minor eucalypts in various combinations. It has a tall scrubby understorey with *Acacia falciformis, Beyeria lasiocarpa, Cassinia* spp., *Notelea venosa* and occasional rainforest elements such as *Ficus rubiginosa* and *Acmena smithii*. Its groundcover is sparse, but large rocks may be covered with *Dendrobium* spp. The tree canopy is open and c. 20 m tall , while small trees and shrubs may be arranged in one or two strata accounting for more than 50% cover. Typical habitat includes rocky slopes and ridgelines on granitoids and metasediments at intermediate elevations. Certain disturbance regimes that include frequent fire and logging may reduce diversity of the understorey. Although this assemblage may be restricted locally, stands are scattered over a wide distribution from Burragate Peak to Mt Imlay with an outlying stand on the slopes of Big Jack Mountain. Its occurrence seems unique to the region, with no similar assemblages known from adjacent regions (Austin 1978, Woodgate et al. 1994). The most similar assemblage nearby appears to be a variant of Rocky Outcrop Scrub (Ecological Vegetation Class 27 described by Woodgate et al. 1994) in gorges of East Gippsland (e.g. Snowy River, Brodribb River). Although this vegetation is dominated by *E. smithii* with *E. elata*, it lacks most of the sub-dominant trees and understorey species, particularly the mesic elements, recorded in the Eden region.

Species richness: 27 ± 3 (0.04 ha)

Extant area: 1205 ha

Proportion cleared: 0%

Number of samples: 13

Table 3a. Diagnostic plant species of Map Unit 3.

Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Acacia falciformis	0.769	2.5(1–3)	0.184	2(1–3)	positive
Australopyrum pectinatum	0.077	1(1–1)	0	0(0–0)	positive
Beyeria lasiocarpa	0.923	3(1–4)	0.023	2(1–2)	positive
Cassinia longifolia	0.615	2(1–2)	0.184	1(1–3)	positive
Cassinia trinerva	0.615	2(1–3)	0.079	1(1–3)	positive
Eucalyptus smithii	0.769	2(1–3)	0.039	2(1–3)	positive
Geitonoplesium cymosum	0.692	2(1–2)	0.105	1(1–2)	positive
Haloragodendron baeuerlenii	0.077	1(1–1)	0	0(0–0)	positive
Notelaea venosa	0.846	2(1–3)	0.107	1(1–1)	positive
Pittosporum undulatum	0.769	1(1–2)	0.086	1(1–2)	frequent
Acmena smithii	0.154	2.5(2–3)	0.031	3(1–4)	uninformative
Brachychiton populneus subsp. *populneus*	0.077	3(3–3)	0.023	1(1–1)	uninformative
Eucalyptus agglomerata	0.385	3(1–3)	0.106	3(2–3)	uninformative
Eucalyptus bosistoana	0.077	1(1–1)	0.053	2(1–3)	uninformative
Eucalyptus cypellocarpa	0.077	1(1–1)	0.316	3(2–3)	uninformative
Eucalyptus elata	0.231	2(2–3)	0.112	3(2–3)	uninformative
Eucalyptus maidenii	0.077	3(3–3)	0.063	3(2–3)	uninformative
Eucalyptus melliodora	0.077	3(3–3)	0.011	1.5(1–3)	uninformative
Eucalyptus muelleriana	0.077	1(1–1)	0.143	3(2–4)	uninformative
Eucalyptus polyanthemos subsp. *vestita*	0.231	1(1–1)	0.012	2(2–3)	uninformative

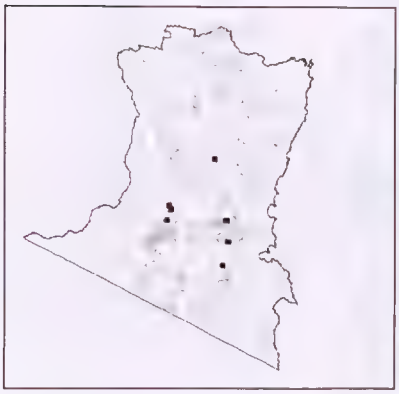
Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Eucalyptus sieberi	0.154	2(2–2)	0.284	3(2–4)	uninformative
Ficus rubiginosa	0.077	1(1–1)	0.009	4(2–6)	uninformative
Lomandra longifolia	0.154	1(1–1)	0.552	2(1–2)	negative
Poa meionectes	0.231	1(1–1)	0.542	2(1–3)	negative
Pteridium esculentum	0.077	1(1–1)	0.581	2(1–3)	negative

Table 3b. Vegetation structure of Map Unit 3. Frequency is the proportion of samples in which strata were present. Height and cover data are means with standard errors in parentheses (n=7).

Stratum	Frequency (%)	Height (m)	Cover (%)
Tree	100	20.0(1.1)	20(2)
Small tree	85.7	9.5(1.1)	20(5)
Shrub	85.7	3.3(0.4)	29(8)
Ground cover	85.7	0.7(0.1)	5(2)

Table 3c. Habitat characteristics of Map Unit 3. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≥ 5°); north (slope > 5° and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		917	898–943	13
Altitude (m)		465	360–540	13
Slope (degrees)		30	23–38	13
Terrain class				
North	46			6
Intermediate	46			6
South	8			1
Flat	0			0
Parent material				
Devonian granitoids	46			6
Devonian high quartz sedimentaries	31			4
Low quartz sedimentaries	8			1
Ordovician high quartz sedimentaries	15			2



Map 3. Distribution of samples of Rocky Tops Dry Scrub Forest (Map Unit 3) shown by large black squares. Samples of other map units shown as small grey points.

Plate 3. Rocky Tops Dry Scrub Forest (Map Unit 3) with *Eucalyptus elata* and *E. sieberi* over a prominent shrub stratum of *Eriostemon trachyphyllus, Dodonaea viscosa* and *Olearia iodochroa* on the eastern upper slope of Big Jack Mountain, Coolangubra section of South East Forests National Park.

Map Unit 4: Acacia Scrub

Acacia Scrub is dominated by a dense canopy of *Acacia silvestris,* rarely with *A. mearnsii,* c. 15 m tall. The understorey is sparse and species-poor with shrubs of *Eriostemon trachyphyllus* and *Pomaderris brogoensis* and minimal groundcover. Other infrequent shrubs include *Prostanthera incisa* and *Beyeria lasiocarpa*. This assemblage occurs in small to moderate-sized patches at moderate elevations in steep gorges on metasediments in the Brogo River and Desert Creek catchments. Most stands are represented in Wadbilliga and Bemboka National Parks, although small stands occur on private and leasehold land at Brogo Pass and Alsops Creek gorge. Acacia Scrub is likely to be eliminated under frequent fire regimes because the dominant species is killed by fire and re-establishment is dependent on a soil seed bank which may take some years for post-fire replenishment. However, Acacia Scrub is unlikely to be readily flammable under moderate fire weather conditions. Long fire-free intervals may also be detrimental as standing plants and seed banks senesce. A large living individual of *A. silvestris* has been aged by ring counts in excess of 100 years (Clayton-Greene and Wimbush 1988). Regeneration of Acacia Scrub is apparently dependent on occasional, high intensity fires. Acacia Scrub extends just north of the study area to Wandella State Forest. Related scrubs are found in the Snowy River gorge to the south west (Clayton-Greene and Wimbush 1988, Forbes et al. 1982, Woodgate et al. 1994, Ecological Vegetation Class 27). Although these assemblages share *A. silvestris* and *E. trachyphyllus* with Acacia Scrub at Brogo, they lack *P. brogoensis* and include several additional *Acacia* spp. and other minor shrub species.

Species richness: 8 ± 2 (0.04 ha)
Extant area: 3585 ha
Proportion cleared: 1%
Number of samples: 13

Table 4a. Diagnostic plant species of Map Unit 4.

Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Acacia silvestris	1	5(4–5)	0.001	2.5(1–4)	positive
Eriostemon trachyphyllus	1	3(1–4)	0.007	1(1–2)	positive
Pomaderris brogoensis	1	3(1–4)	0.002	1(1–3)	positive
Hymenanthera dentata	0.667	1(1–1)	0.069	1(1–2)	frequent
Lomandra longifolia	0	0(1–0)	0.55	2(1–2)	negative
Poa meionectes	0	0(2–0)	0.54	2(1–3)	negative
Pteridium esculentum	0	0(2–0)	0.578	2(1–3)	negative

Table 4b. Vegetation structure of Map Unit 4. Frequency is the proportion of samples in which strata were present. Height and cover data are means with standard errors in parentheses (n=3).

Stratum	Frequency (%)	Height (m)	Cover (%)
Tree	100	15.3(2.7)	65(3)
Small tree	100	7.0(0.6)	37(3)
Shrub	66.7	1.3(0.3)	21(19)
Ground cover	33.3	0.5(-)	1(-)

Table 4c. Habitat characteristics of Map Unit 4. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5° and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		940	923–962	13
Altitude (m)		402	310–500	13
Slope (degrees)		31	27–35	13
Terrain class				
North	38			5
Intermediate	54			7
South	8			1
Flat	0.			0
Parent material				
Devonian high quartz sedimentaries	46			6
Low quartz sedimentaries	23			3
Ordovician high quartz sedimentaries	31			4

Map 4. Distribution of samples of Acacia Scrub (Map Unit 4) shown by large black squares. Samples of other map units shown as small grey points.

Plate 4. Acacia Scrub (Map Unit 4) dominated by *Acacia silvestris* with *Eriostemon trachyphyllus* and scant groundcover, off Bourkes Road, eastern Wadbilliga National Park.

Map Unit 5: Bunga Head Rainforest

Bunga Head Rainforest is dominated by a low (< 10 m) canopy of *Acmena smithii, Ficus rubiginosa* and *Pittosporum undulatum* and *Brachychiton populneus* with emergent *Eucalyptus botryoides*. Its understorey includes large shrubs of *Beyeria, Eupomatia* and *Notelaea*, a diverse range of vines (*Aphanopetalum, Eustrephus, Hibbertia, Marsdenia* and others), small ferns (*Asplenium, Pellaea*) and various graminoids (*Carex, Gahnia* spp., *Oplismenus*). It occurs at a single rocky site on rhyolite by the sea at Bunga Head within Mimosa Rocks National Park. The site is popular with tourists and may be threatened by degradation caused by overuse. Although not highly flammable, the site could be exposed to fires lit by visitors and diversity is likely to be lost if the stand was burnt. Floristic elements with subtropical affinities and high species richness possibly

associated with its coastal location and unusual substrate make this assemblage unique in the region with affinities to rainforest assemblages further north (Floyd 1990).

Species richness: 47 (0.04 ha)

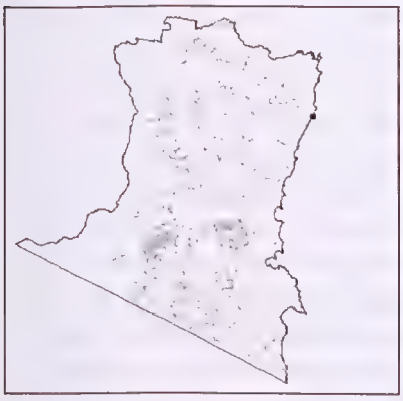
Extant area: 7 ha

Proportion cleared: 0%

Number of samples: 1

Table 5a. Diagnostic plant species of Map Unit 5.

Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Acmena smithii	1	3(3–3)	0.031	3(1–4)	positive
Aphanopetalum resinosum	1	3(3–3)	0.009	2(1–3)	positive
Asplenium flabellifolium	1	2(2–2)	0.121	1(1–2)	positive
Beyeria lasiocarpa	1	3(3–3)	0.031	2(1–3)	positive
Carex appressa	1	2(2–2)	0.084	1(1–2)	positive
Cassytha phaeolasia	1	2(2–2)	0.045	1(1–2)	positive
Entolasia stricta	1	2(2–2)	0.181	1(1–2)	positive
Eupomatia laurina	1	3(3–3)	0.014	3(2–3)	positive
Eustrephus latifolius	1	2(2–2)	0.174	1(1–1)	positive
Ficus rubiginosa	1	4(4–4)	0.009	4(1–6)	positive
Gahnia aspera	1	2(2–2)	0.017	1(1–1)	positive
Gahnia melanocarpa	1	3(3–3)	0.074	1(1–2)	positive
Hibbertia dentata	1	2(2–2)	0.075	1(1–2)	positive
Marsdenia rostrata	1	2(2–2)	0.086	2(1–2)	positive
Notelaea longifolia	1	3(3–3)	0.001	1.5(1–2)	positive
Oplismenus imbecillis	1	2(2–2)	0.108	2(1–2)	positive
Pellaea falcata var. *falcata*	1	3(3–3)	0.097	1(1–2)	positive
Pittosporum undulatum	1	3(3–3)	0.091	1(1–2)	positive
Senecio linearifolius	1	2(2–2)	0.239	1(1–2)	positive
Smilax australis	1	2(2–2)	0.203	1(1–2)	positive
Themeda australis	1	2(2–2)	0.114	2(1–3)	positive
Pteridium esculentum	1	2(2–2)	0.577	2(1–3)	frequent
Lomandra longifolia	0	0(1–0)	0.549	2(1–2)	negative
Poa meionectes	0	0(2–0)	0.539	2(1–3)	negative



Map 5. Distribution of samples of Bunga Head Rainforest (Map Unit 5) shown by large black squares. Samples of other map units shown as small grey points.

Plate 5. Bunga Head Rainforest (Map Unit 5) with wind-pruned *Acmena smithii, Ficus rubiginosa, Myoporum acuminatum* and *Pittosporum undulatum* behind pebbly beach at Bunga Head, northern section Mimosa Rocks National Park.

Table 5b. Vegetation structure of Map Unit 5. Frequency is the proportion of samples in which strata were present. Height and cover data are means with standard errors in parentheses (n=1).

Stratum	Frequency (%)	Height (m)	Cover (%)
Tree	0	-(-)	-(-)
Small tree	100	7.0(-)	75(-)
Shrub	100	1.5(-)	20(-)
Ground cover	100	0.3(-)	45(-)

Table 5c. Habitat characteristics of Map Unit 5. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5° and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		887	887–887	1
Altitude (m)		15	15–15	1
Slope (degrees)		12	12–12	1
Terrain class				
North	0			0
Intermediate	100			1
South	0			0
Flat	0			0
Parent material				
Devonian rhyolite	100			1

Map Unit 6: Coastal Warm Temperate Rainforest

Coastal Warm Temperate Rainforest is dominated by *Acmena smithii* and *Pittosporum undulatum*. Less frequent trees include *Doryphora sassafras, Polyscias murrayi, Acronychia oblongifolia* and others. *Doryphora* may be co-dominant in the northern part of the range. The dense canopy exceeds 15 m in height with emergent eucalypts over 20 m. There are numerous lianas such as *Marsdenia rostrata, Morinda jasminoides* and *Pandorea pandorana*, and sporadic epiphytes including *Korthalsella rubra* and *Sarcochilus* spp. *Eupomatia laurina, Cyathea* spp. and *Dicksonia antarctica* make up a prominent substratum 4 m tall, while a variable groundcover of ferns includes *Blechnum patersonii, Lastreopsis microsora, Microsorium scandens* and *Pteris umbrosa*. The groundcover is often more developed in southern stands. Restricted to steep sheltered gullies on metasedimentary substrates of the coastal ranges usually below 300 m elevation. Although small (usually < 20 ha), the stands are numerous and almost all occur in conservation reserves or State Forests. The topographically restricted distribution of rainforest patches reflect their susceptibility to fires. Even though *A. smithii* and some other species are capable of post-fire coppicing (Ashton and Frankenberg 1976), observations by Floyd (1990) indicate that post-fire recovery of both composition and structure is slow and that the resilience of these rainforests to repeated fires is likely to be poor. Diversity decreases with increasing latitude and altitude (Floyd 1990). Numerous species reach their southern limit within the region, particularly north of Bega (Keith 1990, Keith & Ashby 1992). Notwithstanding these trends, similar forests are found at low elevations to the north as far as Moruya (Helman 1983, Floyd 1990) and south in East Gippsland (Ecological Vegetation Class 32, Woodgate et al. 1994) and Wilsons Promontory (Floyd 1990).

Species richness: 31 ± 2 (0.04 ha)
Extant area: 4143 ha
Proportion cleared: 0%
Number of samples: 15

Table 6a. Diagnostic plant species of Map Unit 6.

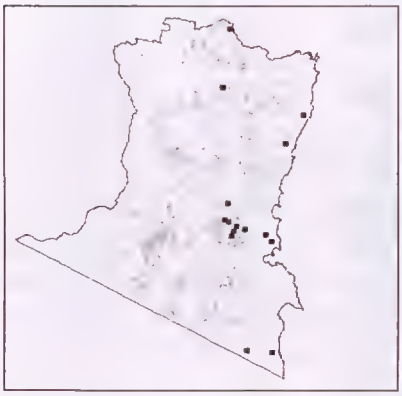
Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Acmena smithii	1	4(4–5)	0.023	2(1–4)	positive
Asplenium flabellifolium	0.539	2(2–2)	0.118	1(1–1)	positive
Blechnum patersonii	0.539	3(2–3)	0.006	1(1–2)	positive
Cissus hypoglauca	0.846	3(3–3)	0.016	1(1–2)	positive
Cyathea australis	0.846	3(2–3)	0.11	1(1–2)	positive
Cyathea leichhardtiana	0.077	4(4–4)	0	0(0–0)	positive
Dicksonia antarctica	0.539	3(3–3)	0.064	2(1–3)	positive
Eupomatia laurina	0.923	3(2–3)	0.007	2(1–3)	positive
Korthalsella rubra subsp. *rubra*	0.077	1(1–1)	0	0(0–0)	positive
Lastreopsis microsora	0.846	4(3–5)	0.007	2(1–3)	positive
Marsdenia rostrata	0.846	2(2–3)	0.08	1(1–2)	positive
Microsorum scandens	0.692	2(1–2)	0.006	3(2–4)	positive
Morinda jasminoides	0.769	2(1–2)	0.017	1(1–2)	positive
Pittosporum undulatum	0.692	2(1–3)	0.086	1(1–2)	positive
Plectorrhiza tridentata	0.077	2(2–2)	0	0(0–0)	positive
Pteris umbrosa	0.539	4(2–5)	0.008	3(2–4)	positive
Sarcochilus australis	0.077	1(1–1)	0	0(0–0)	positive
Smilax australis	0.846	2(2–3)	0.197	1(1–2)	positive
Tmesipteris parva	0.308	1(1–1)	0	0(0–0)	positive
Blechnum cartilagineum	0.923	1.5(1–3)	0.093	2(1–3)	frequent
Notelaea venosa	0.692	1(1–2)	0.108	1(1–1)	frequent
Olearia argophylla	0.615	1.5(1–3)	0.1	2(1–3)	frequent
Pandorea pandorana	0.846	1(1–2)	0.115	1(1–1)	frequent
Acacia melanoxylon	0.231	2(1–3)	0.104	1(1–3)	uninformative
Acacia subporosa	0.154	2.5(2–3)	0.003	1(1–2)	uninformative
Acronychia oblongifolia	0.154	1(1–1)	0.001	1(1–1)	uninformative
Alectryon subcinereus	0.077	2(2–2)	0.007	1(1–2)	uninformative
Backhousia myrtifolia	0.077	3(3–3)	0.002	1(1–4)	uninformative
Doryphora sassafras	0.231	4(3–4)	0.004	3(2–4)	uninformative
Elaeocarpus reticulatus	0.462	1(1–2)	0.073	1(1–2)	uninformative
Eucryphia moorei	0.154	4(3–5)	0.001	3.5(1–6)	uninformative
Pittosporum revolutum	0.154	1(1–1)	0.037	1(1–2)	uninformative
Polyscias murrayi	0.231	3(2–4)	0.001	1(1–1)	uninformative
Synoum glandulosum	0.154	3.5(3–4)	0.005	1(1–2)	uninformative
Lomandra longifolia	0.077	1(1–1)	0.553	2(1–2)	negative
Poa meionectes	0	0(2–0)	0.544	2(1–3)	negative
Pteridium esculentum	0	0(1–0)	0.582	2(1–3)	negative

Table 6b. Vegetation structure of Map Unit 6. Frequency is the proportion of samples in which strata were present. Height and cover data are means with standard errors in parentheses (n=11).

Stratum	Frequency (%)	Height (m)	Cover (%)
Tree	0	-(-)	-(-)
Small tree	100	17.7(1.4)	72(6)
Shrub	100	4.0(0.4)	31(8)
Ground cover	100	0.9(0.1)	60(7)

Table 6c. Habitat characteristics of Map Unit 6. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5° and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		916	884–947	15
Altitude (m)		229	138–365	14
Slope (degrees)		14	6–19	14
Terrain class				
North	21			3
Intermediate	43			6
South	21			3
Flat	14			2
Parent material				
Devonian granitoids	20			3
Devonian high quartz sedimentaries	47			7
Low quartz sedimentaries	20			3
Ordovician high quartz sedimentaries	13			2



Map 6. Distribution of samples of Coastal Warm Temperate Rainforest (Map Unit 6) shown by large black squares. Samples of other map units shown as small grey points.

Plate 6. Coastal Warm Temperate Rainforest (Map Unit 6) dominated by *Acmena smithii* and *Pittosporum undulatum* festooned with *Cissus hypoglauca* and with emergent *Polyscias murrayi* on the highway north of Eden in Bellbird Creek Nature Reserve.

Map Unit 7: Hinterland Warm Temperate Rainforest

Hinterland Warm Temperate Rainforest is dominated by a canopy of *Acmena smithii* c. 15 m tall with emergent *Acacia melanoxylon* over 20 m tall. Other trees, with the exception of *Pittosporum undulatum* in some stands, are not common, although *Doryphora sassafras* and *Eucryphia moorei* may be locally common on the coastal ranges. Lianas include *Marsdenia rostrata, Pandorea pandorana* and *Smilax australis,* while epiphytes are rare. A prominent understorey of shrubs up to 4 m tall includes *Olearia argophylla, Coprosma quadrifida, Pomaderris aspera,* the tree ferns, *Cyathea australis* and *Dicksonia antarctica* and rarely *Elaeocarpus holopetalus*. A semi-continuous ground cover is dominated by ferns, notably *Blechnum cartilagineum, Lastreopsis microsora, Microsorium scandens, Polystichum proliferum, Pteris umbrosa* and the forb, *Australina*

pusilla. Restricted to small patches generally less than 20 ha, in steep sheltered gullies on higher parts of the coastal ranges and in the foothills of the escarpment at 250–700 m elevation. The composition of this unit reflects its transitional status between Coastal Warm Temperate and Cool Temperate Rainforests (Map Units 6 and 8, respectively). Overlap occurs with the former on coastal ranges at Murrabrine and Yurammie and with the latter most notably at Werrinook where the largest stand of rainforest in the region grades from Hinterland Warm Temperate to Cool Temperate with increasing elevation on the escarpment. As for Coastal Warm Temperate Rainforest, almost all stands are in conservation reserves or State Forests and the principal threat is repeated and/or high intensity fires (Floyd 1990). Similar transitional rainforest occurs in gullies below Erinundra Plateau, the Howe and Murrungowar Ranges in East Gippsland, but these total less than 300 ha (Ecological Vegetation Class 33, Woodgate et al. 1994). Similar forests may also occur further north, but these may include additional components, notably *Eucryphia moorei* (Helman 1983, Floyd 1990).

Species richness: 28 ± 3 (0.04 ha)

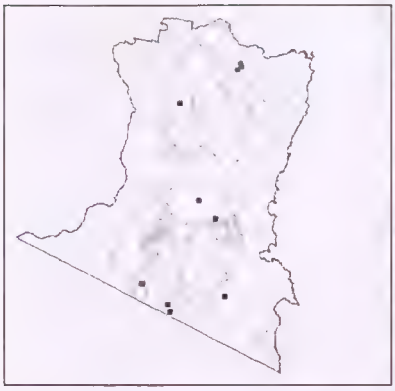
Extant area: 1878 ha

Proportion cleared: 0%

Number of samples: 10

Table 7a. Diagnostic plant species of Map Unit 7.

Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Acacia melanoxylon	0.6	3(2–3)	0.102	1(1–3)	positive
Acmena smithii	1	4(4–5)	0.025	3(1–4)	positive
Asplenium australasicum	0.3	2(1–2)	0	0(0–0)	positive
Asplenium flabellifolium	0.7	2(1–2)	0.118	1(1–2)	positive
Blechnum cartilagineum	0.5	2(2–4)	0.097	2(1–3)	positive
Coprosma quadrifida	0.5	2(1–2)	0.244	1(1–2)	positive
Cyathea australis	0.9	3(2–3)	0.112	1(1–2)	positive
Dicksonia antarctica	0.7	3(2–4)	0.064	2(1–3)	positive
Lastreopsis microsora	0.6	2(2–3)	0.01	4(3–4)	positive
Marsdenia rostrata	0.9	2(2–2)	0.081	2(1–2)	positive
Microsorum scandens	0.7	3(2–4)	0.008	2(1–2)	positive
Olearia argophylla	0.9	2(2–3)	0.099	2(1–3)	positive
Pandorea pandorana	0.9	2(1–2)	0.116	1(1–1)	positive
Polystichum proliferum	0.7	3(2–4)	0.089	2(1–3)	positive
Pomaderris aspera	0.5	2(2–3)	0.159	2(1–3)	positive
Pteris umbrosa	0.8	4(2–5)	0.007	2(2–4)	positive
Pyrrosia rupestris	0.5	2(2–3)	0.019	1(1–2)	positive
Smilax australis	0.8	2(1–3)	0.199	1(1–2)	positive
Australina pusilla	0.6	1.5(1–2)	0.016	1(1–2)	frequent
Pellaea falcata var. *falcata*	0.6	1.5(1–2)	0.094	1(1–2)	frequent
Acronychia oblongifolia	0.1	1(1–1)	0.001	1(1–1)	uninformative
Doryphora sassafras	0.3	4(3–4)	0.004	3(2–4)	uninformative
Elaeocarpus holopetalus	0.3	1(1–3)	0.018	1(1–3)	uninformative
Pittosporum undulatum	0.4	1(1–3)	0.09	1(1–2)	uninformative
Lomandra longifolia	0	0(1–0)	0.553	2(1–2)	negative
Poa meionectes	0.1	2(2–2)	0.542	2(1–3)	negative
Pteridium esculentum	0	0(1–0)	0.581	2(1–3)	negative



Map 7. Distribution of samples of Hinterland Warm Temperate Rainforest (Map Unit 7) shown by large black squares. Samples of other map units shown as small grey points.

Plate 7. Hinterland Warm Temperate Rainforest (Map Unit 7) dominated by *Acmena smithii, Olearia argophylla* and *Acacia melanoxylon* with *Dicksonia antarctica* on Mt Darragh Road in Tantawangalo section of South East Forests National Park.

Table 7b. Vegetation structure of Map Unit 7. Frequency is the proportion of samples in which strata were present. Height and cover data are means with standard errors in parentheses (n=5).

Stratum	Frequency (%)	Height (m)	Cover (%)
Tree	20	22.0(-)	20(-)
Small tree	100	16.4(1.4)	78(4)
Shrub	100	3.8(0.1)	33(8)
Ground cover	100	0.7(0.1)	70(8)

Table 7c. Habitat characteristics of Map Unit 7. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5° and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		966	895–1011	10
Altitude (m)		446	350–500	9
Slope (degrees)		16	10–21	5
Terrain class				
North	0			0
Intermediate	0			0
South	80			4
Flat	20			1
Parent material				
Devonian granitoids	80			8
Ordovician high quartz sedimentaries	20			2

Map Unit 8: Cool Temperate Rainforest

Cool Temperate Rainforest is dominated by a canopy of *Elaeocarpus holopetalus* over 20 m tall occasionally with *Acacia melanoxylon*. A small number of atypical stands are dominated by *Atherosperma moschatum* or *Eucryphia moorei*. Tall emergents of *Eucalyptus fastigata* are occasional. *Parsonsia brownii* is the only liana, while *Hymenophyllum* spp., *Grammitis billardieri, Tmesipteris* spp. and *Fieldia australis* are epiphytic on tree fern trunks. The tree fern *Dicksonia antarctica* dominates a prominent understorey 4 m tall with occasional shrubs of *Tasmannia lanceolata* and *Coprosma quadrifida*. Ferns, notably *Blechnum wattsii, Histiopteris incisa* and the forb, *Fieldia australis* dominate a prominent groundcover. Cool Temperate Rainforest is restricted to small patches generally less than 20 ha, in sheltered gullies on higher parts of the escarpment range above 700 m elevation. Outliers occur at this elevation below the summits of Burragate Peak and Mt Imlay. Most stands occur in conservation reserves, with a few in State Forest south of Brown Mountain. Stands of this rainforest may be eliminated by a single high intensity fire, since the dominant species is killed and relies on dispersal from unburnt stands for re-establishment (e.g. Noble & Slatyer 1981). Cool Temperate Rainforest was reportedly eliminated from Mt Darragh by an intense fire in 1942 (F. Carey, pers. comm.). The present vegetation of this site is Layered Brown Barrel Forest (Map Unit 10) with a single remnant individual of *E. holopetalus*. *Eucryphia moorei* is more common in Cool Temperate Rainforests further north (Helman 1983), while *A. moschatum* is more common in rainforests in East Gippsland (Ecological Vegetation Class 31, Woodgate et al. 1994). Although not surveyed, the bryophyte flora may be species-rich in the Eden cool temperate rainforests as it is in those of East Gippsland (Woodgate et al. 1994).

Species richness: 17 ± 2 (0.04 ha)
Extant area: 844 ha
Proportion cleared: 3%
Number of samples: 7

Table 8a. Diagnostic plant species of Map Unit 8.

Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Blechnum wattsii	1	4(4–5)	0.042	2(1–3)	positive
Dicksonia antarctica	1	5(3–5)	0.065	2(1–3)	positive
Elaeocarpus holopetalus	0.8	4.5(3–6)	0.017	1(1–2)	positive
Fieldia australis	0.6	3(1–3)	0.018	1.5(1–2)	positive
Grammitis billardieri	0.6	2(1–2)	0	0(0–0)	positive
Hymenophyllum flabellatum	0.2	1(1–1)	0	0(0–0)	positive
Hypolepis amaurorachis	0.2	1(1–1)	0	0(0–0)	positive
Tasmannia lanceolata	0.6	2(1–3)	0.042	2(1–3)	positive
Uncinia tenella	0.2	1(1–1)	0	0(0–0)	positive
Coprosma quadrifida	0.6	1(1–1)	0.245	1(1–2)	frequent
Gahnia sieberiana	0.6	1(1–3)	0.075	1(1–2)	frequent
Histiopteris incisa	0.8	1(1–3)	0.016	1(1–1)	frequent
Hymenophyllum cupressiforme	0.6	1(1–3)	0.01	1(1–2)	frequent
Parsonsia brownii	0.8	1.5(1–3)	0.025	1(1–2)	frequent
Acacia dealbata	0.4	2.5(0–3)	0.137	2(0–3)	uninformative
Acacia melanoxylon	0.2	3(3–3)	0.105	1(1–3)	uninformative
Atherosperma moschatum	0.2	4(4–4)	0.001	2(2–2)	uninformative

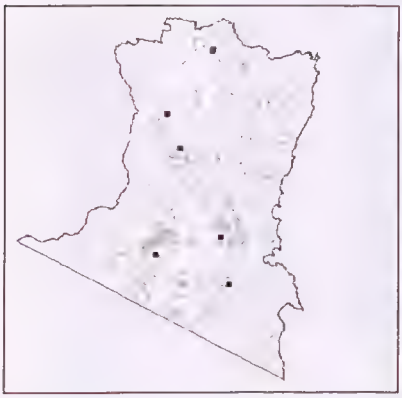
Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Eucalyptus fastigata	0.2	3(3–3)	0.14	3(3–4)	uninformative
Eucryphia moorei	0.2	6(6–6)	0.002	3(1–5)	uninformative
Pittosporum bicolor	0.4	1(1–1)	0.007	1(1–1)	uninformative
Lomandra longifolia	0	0(1–0)	0.551	2(1–2)	negative
Poa meionectes	0	0(1–0)	0.541	2(1–3)	negative
Pteridium esculentum	0	0(1–0)	0.579	2(1–3)	negative

Table 8b. Vegetation structure of Map Unit 8. Frequency is the proportion of samples in which strata were present. Height and cover data are means with standard errors in parentheses (n=4).

Stratum	Frequency (%)	Height (m)	Cover (%)
Tree	25	40.0(-)	10(-)
Small tree	100	23.5(1.7)	74(8)
Shrub	100	3.8(0.4)	35(12)
Ground cover	100	0.7(0.2)	48(16)

Table 8c. Habitat characteristics of Map Unit 8. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5°and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		1041	911–1208	7
Altitude (m)		910	819–1038	7
Slope (degrees)		19	8–29	7
Terrain class				
North	0			0
Intermediate	43			3
South	29			2
Flat	29			2
Parent material				
Devonian granitoids	57			4
Devonian high quartz sedimentaries	14			1
Low quartz sedimentaries	29			2



Map 8. Distribution of samples of Cool Temperate Rainforest (Map Unit 8) shown by large black squares. Samples of other map units shown as small grey points.

Plate 8. Cool Temperate Rainforest (Map Unit 8) dominated by *Eucryphia moorei* with *Lastreopsis microsora* and other ferns below Burragate Peak, Yowaka section of South East Forests National Park.

Map Unit 9: High Mountain Wet Layered Forest

These forests dominated by *Eucalyptus nitens* and *E. fastigata* may exceed 60 m in height and commonly exceed 40 m. Northern stands may include *E. badjensis* and *E. fraxinoides* as minor components. A distinctive dense subcanopy of small trees c. 10 m tall includes *Acacia dealbata, Olearia argophylla* and *Prostanthera lasianthos.* Occasional vines include *Parsonsia brownii* and *Clematis aristata.* An understorey c. 3 m tall comprises *Dicksonia antarctica* and *Coprosma quadrifida.* The groundcover comprises scattered clumps of *Polystichum proliferum* and *Gahnia sieberiana* amongst typically dense leaf litter. These magnificent forests are scattered along the highest parts of the escarpment range above 850 m elevation, mainly on granitoid geology. Although the northern stands in the Brown Mountain–upper Tantawangalo area have been fragmented by recent logging, some of these are now reserved from further logging. In the south, a stand near the Victorian border was partially cleared for pine plantations in the 1970s (about one-fifth of the total area) and the remainder was burnt by an intense crown fire in 1983. Similar forests have been described on Erinundra Plateau in East Gippsland (Community 8.1, Forbes et al. 1982), but some differences are apparent including rainforest elements such as *Atherosperma moschatum* in the subcanopy and a greater frequency of shrubs (e.g. *Telopea oreades*) in the understorey. Although no detailed studies have been carried out on the dynamics of High Mountain Layered Wet Forest, it is likely that Ashton's (1981) stand-replacing fire model accurately describes vegetation change in relation to recurring disturbance (see also Noble and Slatyer 1981). The existence of stands dominated by *A. dealbata* south of Brown Mountain is consistent with the prior elimination of eucalypts as proposed in a pathway of Ashton's (1981) model that entails frequent fires. Although such fire regimes potentially threaten all reserved stands of Mountain Layered Wet Forest, these threats are likely to be amplified in stands that remain in production because they are subject to additional disturbances including tree-felling and management fires. Dense and rapid vegetative recovery of ferns that follows logging and regeneration burns may also suppress establishment of seedlings, reducing the diversity of woody species including trees.

Species richness: 21 ± 2 (0.04 ha)
Extant area: 1815 ha
Proportion cleared: 20%
Number of samples: 11

Table 9a. Diagnostic plant species of Map Unit 9.

Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Acacia dealbata	0.909	3.5(3–4)	0.132	2(1–3)	positive
Coprosma quadrifida	0.546	2(2–3)	0.244	1(1–2)	positive
Dicksonia antarctica	0.909	2.5(1–3)	0.062	2(1–3)	positive
Eucalyptus fastigata	0.636	3(3–5)	0.137	3(3–4)	positive
Eucalyptus nitens	0.727	4(3–4)	0.007	3(3–4)	positive
Olearia argophylla	1	4(3–4)	0.098	2(1–3)	positive
Parsonsia brownii	0.546	2(1–3)	0.023	1(1–2)	positive
Polystichum proliferum	0.818	3(2–5)	0.088	2(1–3)	positive
Prostanthera lasianthos	0.636	3(1–3)	0.06	1(1–2)	positive
Clematis aristata	0.818	1(1–1)	0.337	1(1–1)	frequent

Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Gahnia sieberiana	0.727	1.5(1–2)	0.072	1(1–3)	frequent
Acacia melanoxylon	0.182	2.5(2–3)	0.105	1(1–3)	uninformative
Elaeocarpus holopetalus	0.091	3(3–3)	0.019	1(1–3)	uninformative
Eucalyptus badjensis	0.182	3(3–3)	0.006	3(2–4)	uninformative
Eucalyptus elata	0.091	3(3–3)	0.113	3(2–3)	uninformative
Eucalyptus fraxinoides	0.091	4(4–4)	0.028	4(3–4)	uninformative
Eucalyptus obliqua	0.091	2(2–2)	0.19	3(2–4)	uninformative
Lomandra longifolia	0	0(1–0)	0.553	2(1–2)	negative
Poa meionectes	0	0(1–0)	0.543	2(1–3)	negative
Pteridium esculentum	0.455	1(1–2)	0.578	2(1–3)	negative

Table 9b. Vegetation structure of Map Unit 9. Frequency is the proportion of samples in which strata were present. Height and cover data are means with standard errors in parentheses (n=10).

Stratum	Frequency (%)	Height (m)	Cover (%)
Tree	100	43.0(3.4)	45(4)
Small tree	100	9.8(1.8)	46(8)
Shrub	80	2.7(0.4)	25(6)
Ground cover	100	0.8(0.2)	35(9)

Table 9c. Habitat characteristics of Map Unit 9. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5° and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		1063	916–1202	11
Altitude (m)		923	840–1000	11
Slope (degrees)		15	9–21	11
Terrain class				
North	18			2
Intermediate	18			2
South	64			7
Flat	0			0
Parent material				
Devonian granitoids	91			10
Ordovician high quartz sedimentaries	9			1

Map 9. Distribution of samples of High Mountain Wet Layered Forest (Map Unit 9) shown by large black squares. Samples of other map units shown as small grey points.

Plate 9. High Mountain Wet Layered Forest (Map Unit 9) with *Eucalyptus nitens* emergent over a subcanopy of *Acacia dealbata* and *Prostanthera lasianthos* on Obliqua Road in Glenbog State Forest.

Map Unit 10: Mountain Wet Layered Forest

Although structurally similar to the preceding assemblage (Map Unit 9), these forests exceeding 35 m in height are usually dominated by pure stands of *Eucalyptus fastigata* or may have a minor component of *E. cypellocarpa*. The principal subcanopy species are *Bedfordia arborescens, Olearia argophylla* and *Pomaderris aspera* and these typically reach a height of 10 m in high densities. The understorey is dominated by *Dicksonia antarctica* with *Coprosma quadrifida*, often tangled with *Smilax australis* and *Clematis aristata*, while the groundcover comprises ferns, *Polystichum proliferum* and *Pteridium esculentum*, and scattered herbs such as *Stellaria flaccida* and *Viola hederacea*. Mountain Wet Layered Forest typically occurs in large stands on moist granitoid slopes at 600–1000 m elevation (generally lower than Map Unit 9), although small unusual stands occur on metasediments and at lower elevation in sheltered gullies. The major stands occur on the escarpment range between Brown Mountain and the upper Tantawangalo Creek area, at Mt Darragh, in the upper Wog Wog River and on Egan Peaks. A similar model of vegetation dynamics is likely to apply to Mountain Wet Layered Forests as described previously for layered forests at higher elevation (Map Unit 9). Frequent disturbance regimes are therefore likely to entail similar adverse ecological consequences. Similar assemblages have not been explicitly described in adjacent regions. However, such vegetation may exist within wet sclerophyll complexes on Erinundra and Nunniong Plateaux in East Gippsland (Woodgate et al. 1994). For example, Mountain Wet Layered Forest in Eden shares some features of East Gippsland Community 8.1 and other features of 8.2 described by Forbes et al. (1982).

Species richness: 29 ± 1 (0.04 ha)
Extant area: 18 091 ha
Proportion cleared: 10%
Number of samples: 82

Map 10. Distribution of samples of Mountain Wet Layered Forest (Map Unit 10) shown by large black squares. Samples of other map units shown as small grey points.

Plate 10. Mountain Wet Layered Forest (Map Unit 10) dominated by *Eucalyptus fastigata* with a subcanopy of *Bedfordia arborescens* on the watershed between Wog Wog River and Basin Creek, Coolangubra section, South East Forests National Park.

Table 10a. Diagnostic plant species of Map Unit 10.

Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Bedfordia arborescens	0.8	3.5(3–4)	0.114	2(1–3)	positive
Coprosma quadrifida	0.825	2(1–2)	0.213	1(1–2)	positive
Dicksonia antarctica	0.525	2(1–3)	0.042	2(1–3)	positive
Eucalyptus fastigata	0.925	4(3–4)	0.096	3(2–4)	positive
Olearia argophylla	0.838	3(1–3)	0.063	1(1–3)	positive
Polystichum proliferum	0.763	3(1–3)	0.055	2(1–2)	positive
Pomaderris aspera	0.875	3(2–4)	0.121	1.5(1–3)	positive
Smilax australis	0.713	2(1–2)	0.174	1(1–2)	positive
Stellaria flaccida	0.638	2(1–2)	0.187	1(1–2)	positive
Pteridium esculentum	0.688	2(1–2)	0.57	2(1–3)	frequent
Clematis aristata	0.75	1(1–1)	0.318	1(1–1)	frequent
Viola hederacea subsp. *hederacea*	0.763	1(1–2)	0.419	2(1–2)	frequent
Acacia dealbata	0.45	3(2–4)	0.12	2(1–3)	uninformative
Acacia melanoxylon	0.363	1(1–3)	0.091	1(1–3)	uninformative
Eucalyptus badjensis	0.075	3.5(2–4)	0.004	3(2–4)	uninformative
Eucalyptus cypellocarpa	0.388	3(1–3)	0.31	3(2–3)	uninformative
Eucalyptus dalrympleana subsp. *dalrympleana*	0.013	1(1–1)	0.019	3(1–3)	uninformative
Eucalyptus elata	0.038	2(1–2)	0.117	3(2–3)	uninformative
Eucalyptus fraxinoides	0.075	2.5(1–3)	0.026	4(3–4)	uninformative
Eucalyptus globoidea	0.025	1(1–1)	0.255	3(1–3)	uninformative
Eucalyptus maidenii	0.013	2(2–2)	0.066	3(2–3)	uninformative
Eucalyptus nitens	0.063	3(3–4)	0.009	4(3–4)	uninformative
Eucalyptus obliqua	0.1	1(1–2)	0.195	3(2–4)	uninformative
Eucalyptus radiata	0.013	3(3–3)	0.08	3(1–3)	uninformative
Eucalyptus sieberi	0.013	1(1–1)	0.298	3(2–4)	uninformative
Eucalyptus smithii	0.013	2(2–2)	0.047	2(1–3)	uninformative
Eucalyptus viminalis	0.025	2(1–3)	0.059	3(1–3)	uninformative
Lomandra longifolia	0.2	1(1–2)	0.569	2(1–2)	negative
Poa meionectes	0.288	1(1–2)	0.553	2(1–3)	negative

Table 10b. Vegetation structure of Map Unit 10. Frequency is the proportion of samples in which strata were present. Height and cover data are means with standard errors in parentheses (n=42).

Stratum	Frequency (%)	Height (m)	Cover (%)
Tree	97.6	35.1(1.2)	38(3)
Small tree	100	10.2(0.5)	54(4)
Shrub	71.4	2.6(0.3)	25(4)
Ground cover	100	0.7(0.1)	40(3)

Table 10c. Habitat characteristics of Map Unit 10. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5°and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		973	911–1014	82
Altitude (m)		811	730–910	81
Slope (degrees)		11	5–15	78
Terrain class				
North	4			3
Intermediate	35			27

South	38	30
Flat	23	18
Parent material		
Devonian granitoids	84	69
Devonian high quartz sedimentaries	4	3
Low quartz sedimentaries	1	1
Tertiary Basalt	11	9

Map Unit 11: Tantawangalo Wet Shrub Forest

Tantawangalo Wet Shrub Forest is a tall forest dominated by *Eucalyptus obliqua, E. cypellocarpa* and *E. fastigata.* Its prominent and diverse shrub stratum distinguishes it from other wet eucalypt forest assemblages. Typical species include *Tasmannia lanceolata, Acacia melanoxylon, Bedfordia arborescens, Pomaderris aspera* and *Hakea eriantha.* The understorey is dominated by *Dicksonia antarctica* with *Coprosma quadrifida,* often tangled with *Billardiera scandens, Clematis aristata, Smilax australis* and *Tylophora barbata.* The groundcover is dominated by graminoids and lilioids such as *Gahnia sieberiana, Dianella tasmanica* and *Lepidosperma laterale.* This distinctive forest assemblage is restricted to the upper Tantawangalo Creek area on moderate granitoid slopes at 800–1000 m elevation. Almost all occurrences are represented within South East Forests National Park. While there are no immediate threats, diversity of the shrubby understorey may be reduced if fire frequency increases significantly in future. There are apparently no similar forest assemblages outside the Eden region (Costin 1954, Austin 1978, Forbes et al. 1982, Woodgate et al. 1994).

Species richness: 31 ± 1 (0.04 ha)

Extant area: 808 ha

Proportion cleared: 0%

Number of samples: 18

Table 11a. Diagnostic plant species of Map Unit 11.

Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Acacia melanoxylon	0.778	4(3–4)	0.097	1(1–2)	positive
Bedfordia arborescens	0.611	3(2–3)	0.145	2(1–4)	positive
Eucalyptus cypellocarpa	0.944	3(3–4)	0.306	3(2–3)	positive
Eucalyptus fastigata	0.833	4(4–4)	0.132	3(3–4)	positive
Eucalyptus obliqua	0.944	4(3–5)	0.18	3(2–4)	positive
Gahnia sieberiana	0.722	3(1–3)	0.069	1(1–2)	positive
Pomaderris aspera	0.667	3(1–3)	0.155	2(1–3)	positive
Tasmannia lanceolata	1	3(1–3)	0.032	1.5(1–3)	positive
Billardiera scandens	0.833	1(1–1)	0.323	1(1–1)	frequent
Clematis aristata	0.944	1(1–1)	0.334	1(1–1)	frequent
Coprosma quadrifida	0.889	1(1–1)	0.238	1(1–2)	frequent
Dianella tasmanica	0.722	1(1–1)	0.229	1(1–2)	frequent
Gonocarpus teucrioides	0.722	1(1–1)	0.311	2(1–2)	frequent
Goodenia ovata	0.722	1(1–3)	0.166	2(1–2)	frequent
Hakea eriantha	0.667	1(1–3)	0.059	1(1–2)	frequent
Lepidosperma laterale	0.722	1(1–3)	0.34	1(1–2)	frequent
Leucopogon lanceolatus var. *lanceolatus*	0.611	1(1–1)	0.403	1(1–2)	frequent
Olearia argophylla	0.722	1(1–2)	0.097	2(1–3)	frequent
Smilax australis	0.889	1(1–1)	0.195	1(1–2)	frequent
Tylophora barbata	0.667	1(1–1)	0.262	2(1–2)	frequent

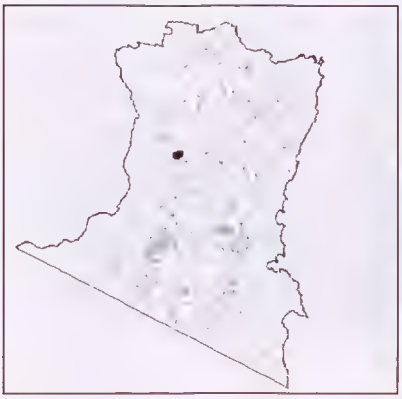
Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Viola hederacea subsp. *hederacea*	1	1(1–1)	0.431	2(1–2)	frequent
Acacia dealbata	0.278	1(1–3)	0.136	2(1–3)	uninformative
Elaeocarpus holopetalus	0.556	1(1–1)	0.013	2(1–3)	uninformative
Eucalyptus elata	0.278	3(2–3)	0.111	3(2–3)	uninformative
Eucalyptus radiata	0.222	3(2–4)	0.075	3(1–3)	uninformative
Eucalyptus sieberi	0.167	3(3–5)	0.284	3(2–4)	uninformative
Lomandra longifolia	0.889	1(1–1)	0.545	2(1–2)	negative
Poa meionectes	0.556	1(1–1)	0.539	2(1–3)	negative
Pteridium esculentum	1	1(1–1)	0.572	2(1–3)	negative

Table 11b. Vegetation structure of Map Unit 11. Frequency is the proportion of samples in which strata were present. Height data are unavailable. Cover data are means with standard errors in parentheses (n=18).

Stratum	Frequency (%)	Height (m)	Cover (%)
Tree	100	-	39(2)
Small tree	88.9	-	19(3)
Shrub	100	-	33(3)
Ground cover	100	-	25(2)

Table 11c. Habitat characteristics of Map Unit 11. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5° and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		957	952–960	18
Altitude (m)		890	865–908	1
Slope (degrees)		6–10	18	
Terrain class				
North	33			6
Intermediate	22			4
South	22			4
Flat	22			4
Parent material				
Devonian granitoids	100			18



Map 11. Distribution of samples of Tantawangalo Wet Shrub Forest (Map Unit 11) shown by large black squares. Samples of other map units shown as small grey points.

Plate 11. Tantawangalo Wet Shrub Forest (Map Unit 11) dominated by *Eucalyptus cypellocarpa* with *E. fastigata* over an open stratum of *Bedfordia arborescens*, *Exocarpos strictus* and *Olearia argophylla* on Robinsons Road in the upper Tantawangalo Creek catchment, Tantawangalo section of South East Forests National Park.

Map Unit 12: Mountain Wet Fern Forest

Mountain Wet Fern Forest is dominated by *Eucalyptus fastigata* and *E. cypellocarpa* exceeding 32 m in height. Tree ferns *Cyathea australis* and tall shrubs of *Bedfordia arborescens* sometimes form an open stratum c. 10 m tall, while scattered shrubs of *Coprosma quadrifida, Pimelea axiflora* and *Senecio linearifolius* emerge from a prominent groundcover of ferns *Blechnum nudum* and *Pteridium esculentum.* Interstitial herbs of the ground stratum include *Geranium potentilloides, Stellaria flaccida* and *Viola hederacea.* The vines *Tylophora barbata* and *Smilax australis,* and the grass *Hierochloe rariflora* trail amongst groundcover ferns. Mountain Wet Fern Forest occurs on steep sheltered granitoid slopes at 450–900 m elevation on the escarpment range and outlying mountains such as Egan Peaks and Mt Poole. Mountain Wet Fern Forest is most similar to Mountain Wet Layered Forest (Map Unit 10), but differs in the presence of minor tree species and greater abundance of *E. cypellocarpa,* its more open subcanopy and in the composition and greater diversity of its understorey. The diversity of this assemblage may be affected by regimes of frequent and/or intense disturbances (i.e. fires and logging). Dense and rapid vegetative recovery of ferns that follows logging and regeneration burns may suppress establishment of seedlings, reducing the diversity of woody species including trees. Frequent burning is likely to exacerbate this effect, although these threats are not ubiquitous in Mountain Wet Fern Forest, since about two-thirds of its extent is represented within conservation reserves. Similar assemblages may exist in the wet forest complex of East Gippsland (Ecological Vegetation Class 30, Woodgate et al. 1994), but this needs further investigation.

Species richness: 33 ± 2 (0.04 ha)

Extant area: 2279 ha

Proportion cleared: 2%

Number of samples: 31

Table 12a. Diagnostic plant species of Map Unit 12.

Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Bedfordia arborescens	0.677	2(2–4)	0.14	2(1–3)	positive
Blechnum nudum	0.613	4(3–5)	0.068	2(1–3)	positive
Coprosma quadrifida	0.742	2(1–2)	0.235	1(1–2)	positive
Cyathea australis	0.548	3(2–3)	0.108	1(1–2)	positive
Eucalyptus cypellocarpa	0.903	3(3–4)	0.301	3(2–3)	positive
Eucalyptus fastigata	0.807	3(3–4)	0.126	3(3–4)	positive
Geranium potentilloides	0.807	2(1–2)	0.203	1(1–2)	positive
Hierochloe rariflora	0.613	2(2–3)	0.173	2(1–3)	positive
Pimelea axiflora	0.71	2(1–2)	0.106	1(1–2)	positive
Senecio linearifolius	0.613	2(1–2)	0.232	1(1–2)	positive
Stellaria flaccida	0.839	2(1–2)	0.198	1(1–2)	positive
Tylophora barbata	0.839	2(1–2)	0.255	2(1–2)	positive
Viola hederacea subsp. *hederacea*	0.871	2(1–2)	0.428	2(1–2)	positive
Poa meionectes	0.613	2(1–3)	0.537	2(1–3)	frequent
Pteridium esculentum	1	2(2–4)	0.568	2(1–3)	frequent
Hydrocotyle acutiloba	0.645	1(1–2)	0.187	1(1–2)	frequent
Smilax australis	0.807	1(1–2)	0.19	1(1–2)	frequent
Acacia melanoxylon	0.258	2(1–3)	0.102	1(1–3)	uninformative
Eucalyptus badjensis	0.032	5(5–5)	0.007	3(2–4)	uninformative
Eucalyptus croajingolensis	0.032	2(2–2)	0.002	3(2–3)	uninformative

Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Eucalyptus elata	0.129	4(3–4)	0.112	3(2–3)	uninformative
Eucalyptus globoidea	0.065	1.5(1–2)	0.246	3(1–3)	uninformative
Eucalyptus muelleriana	0.032	3(3–3)	0.144	3(2–4)	uninformative
Eucalyptus obliqua	0.387	2(1–3)	0.185	3(2–4)	uninformative
Eucalyptus radiata	0.097	2(2–3)	0.076	3(1–3)	uninformative
Eucalyptus sieberi	0.032	1(1–1)	0.288	3(2–4)	uninformative
Lomandra longifolia	0.29	1(1–2)	0.555	2(1–2)	negative

Table 12b. Vegetation structure of Map Unit 12. Frequency is the proportion of samples in which strata were present. Height and cover data are means with standard errors in parentheses (n=25).

Stratum	Frequency (%)	Height (m)	Cover (%)
Tree	100	33.1(1.5)	45(3)
Small tree	64	9.9(1.9)	34(7)
Shrub	96	2.9(0.3)	22(4)
Ground cover	100	1.0(0.1)	59(6)

Table 12c. Habitat characteristics of Map Unit 12. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5° and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		1018	996–1039	3
Altitude (m)		695	660–763	31
Slope (degrees)		15	5–26	31
Terrain class				
North	6			2
Intermediate	35			11
South	45			14
Flat	13			4
Parent material				
Devonian granitoids	94			29
Ordovician high quartz sedimentaries	6			2

Map 12. Distribution of samples of Mountain Wet Fern Forest (Map Unit 12) shown by large black squares. Samples of other map units shown as small grey points.

Plate 12. Mountain Wet Fern Forest (Map Unit 12) dominated by *Eucalyptus fastigata* with a dense groundcover of *Blechnum nudum* near Mt Darragh, Tantawangalo section of South East Forests National Park.

Map Unit 13: Hinterland Wet Fern Forest

Hinterland Wet Fern Forest is a diverse mesic assemblage dominated by *Eucalyptus cypellocarpa* and numerous less frequent tree species over 30 m tall. One or two open strata of shrubs c. 2–9 m tall include *Pomaderris aspera* and several less frequent species. The dense groundcover is dominated by ferns, *Calochlaena dubia, Blechnum cartilagineum, Doodia aspera* and *Pteridium esculentum.* Herbs including *Desmodium varians, Stellaria flaccida* and *Viola hederacea* and the grass *Poa meionectes* are common amongst the large clumps of ferns. Vines growing amongst the groundcover and shrubs include *Tylophora barbata, Smilax australis, Eustrephus latifolius* and *Glycine clandestina.* Hinterland Wet Fern Forest is widespread in gullies and moist sheltered slopes in relatively large stands below 800 m elevation. In the higher part of its altitudinal range it is replaced by Mountain Wet Fern Forest (Map Unit 12) or Mountain Wet Herb Forest (Map Unit 15) which differ in their understorey composition and greater abundance of *E. fastigata.* Although most extensive on granitoid substrates of the escarpment and hinterland, it is also common on metasediments, particularly on central parts of the coastal range west of Merimbula. Restricted stands occur in coastal gullies in the Nadgee area. Clearing is a potential threat over the 8000 ha of Hinterland Wet Fern Forest that occur on private land. Logging may also threaten the diversity of woody species including trees where dense and rapid vegetative recovery of ferns after regeneration burns suppresses establishment of seedlings. Frequent burning is likely to exacerbate pressure on populations of woody species, especially in combination with logging or partial clearing activities. However, the threats posed by clearing, logging and frequent burning are not ubiquitous in Hinterland Wet Fern Forest, since about half of its extent is represented within conservation reserves. A similar assemblage has been described in East Gippsland (Community 13.2, Forbes et al. 1982) within the extensive damp forest complex (Ecological vegetation Class 29, Woodgate et al. 1994).

Map 13. Distribution of samples of Hinterland Wet Fern Forest (Map Unit 13) shown by large black squares. Samples of other map units shown as small grey points.

Plate 13. Hinterland Wet Fern Forest (Map Unit 13) dominated by *Eucalyptus cypellocarpa* with a dense groundcover of *Calochlaena dubia* in the upper New England Creek catchment, Murrabrine section of Wadbilliga National Park.

Species richness: 40 ± 1 (0.04 ha)
Extant area: 43 190 ha
Proportion cleared: 6%
Number of samples: 75

Table 13a. Diagnostic plant species of Map Unit 13.

Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Blechnum cartilagineum	0.614	2(1–4)	0.074	2(1–3)	positive
Calochlaena dubia	0.657	3.5(2–5)	0.085	2(1–3)	positive
Desmodium varians	0.629	2(1–2)	0.231	1(1–2)	positive
Doodia aspera	0.671	2(2–3)	0.074	2(1–2)	positive
Eucalyptus cypellocarpa	0.843	3(3–3)	0.287	3(2–3)	positive
Omalanthus populifolius	0.014	1(1–1)	0	0(0–0)	positive
Pomaderris aspera	0.557	2(1–3)	0.142	2(1–3)	positive
Psychotria loniceroides	0.014	1(1–1)	0	0(0–0)	positive
Schizomeria ovata	0.014	1(1–1)	0	0(0–0)	positive
Smilax australis	0.771	2(1–2)	0.175	1(1–2)	positive
Tylophora barbata	0.929	2(1–2)	0.234	1(1–2)	positive
Poa meionectes	0.729	2(1–3)	0.529	2(1–3)	frequent
Pteridium esculentum	0.786	2(2–3)	0.566	2(1–3)	frequent
Eustrephus latifolius	0.6	1(1–2)	0.153	1(1–1)	frequent
Glycine clandestina	0.671	1(1–2)	0.31	1(1–2)	frequent
Stellaria flaccida	0.657	1(1–2)	0.189	1(1–2)	frequent
Viola hederacea subsp. *hederacea*	0.786	1(1–2)	0.42	2(1–2)	frequent
Acacia melanoxylon	0.243	1(1–3)	0.098	1(1–3)	uninformative
Acmena smithii	0.171	1(1–3)	0.025	4(2–4)	uninformative
Angophora floribunda	0.071	2(2–3)	0.096	2(1–3)	uninformative
Corymbia gummifera	0.029	2(2–2)	0.02	3(2–4)	uninformative
Eucalyptus agglomerata	0.057	2(1–3)	0.111	3(2–3)	uninformative
Eucalyptus baxteri	0.014	3(3–3)	0.008	3(2–3)	uninformative
Eucalyptus elata	0.271	3(2–4)	0.105	3(2–3)	uninformative
Eucalyptus fastigata	0.271	3(2–4)	0.134	3(3–4)	uninformative
Eucalyptus fraxinoides	0.014	3(3–3)	0.029	4(3–4)	uninformative
Eucalyptus globoidea	0.171	2(1–3)	0.246	3(1–3)	uninformative
Eucalyptus maidenii	0.029	2.5(2–3)	0.065	3(2–3)	uninformative
Eucalyptus muelleriana	0.443	3(2–4)	0.127	3(3–4)	uninformative
Eucalyptus obliqua	0.157	4(2–4)	0.191	3(2–4)	uninformative
Eucalyptus radiata	0.014	1(1–1)	0.08	3(1–3)	uninformative
Eucalyptus sieberi	0.143	1.5(1–4)	0.29	3(2–4)	uninformative
Eucalyptus smithii	0.071	1(1–4)	0.044	2(1–3)	uninformative
Eucalyptus viminalis	0.014	1(1–1)	0.059	3(1–3)	uninformative
Eucryphia moorei	0.014	1(1–1)	0.002	5(3–6)	uninformative
Lomandra longifolia	0.429	1.5(1–2)	0.555	2(1–2)	negative

Table 13b. Vegetation structure of Map Unit 13. Frequency is the proportion of samples in which strata were present. Height and cover data are means with standard errors in parentheses (n=44).

Stratum	Frequency (%)	Height (m)	Cover (%)
Tree	100	31.5(1.2)	34(2)
Small tree	79.5	8.9(0.8)	31(3)
Shrub	93.2	2.1(0.2)	21(3)
Ground cover	100	0.7(0.1)	57(4)

Table 13c. Habitat characteristics of Map Unit 13. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5°and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		933	877–974	75
Altitude (m)		389	180–550	67
Slope (degrees)		16	4–26	62
Terrain class				
North	13			8
Intermediate	27			17
South	32			20
Flat	27			17
Parent material				
Devonian granitoids	44			33
Devonian high quartz sedimentaries	20			15
Low quartz sedimentaries	19			14
Ordovician high quartz sedimentaries	16			12
Tertiary Alluvium	1			1

Map Unit 14: Hinterland Wet Shrub Forest

Hinterland Wet Shrub Forest is dominated by *Eucalyptus muelleriana* with *E. cypellocarpa* over 30 m tall. The understorey includes prominent strata of small trees and shrubs c. 3–9 m tall including *Acacia cognata, Elaeocarpus reticulatus, Goodenia ovata* and *Leucopogon lanceolatus*. The groundcover is dominated by forbs, *Gonocarpus teucrioides* and *Viola hederacea* and grasses, *Tetrarrhena juncea* and *Poa meionectes* with scattered fronds of *Pteridium esculentum*. Vines growing amongst the groundcover and shrubs include *Hibbertia dentata, Smilax australis, Tylophora barbata, Billardiera scandens* and *Clematis aristata*. Hinterland Wet Shrub Forest is widespread in gullies and steep moist sheltered slopes below 500 m elevation predominantly on metasediments of the coastal ranges. Outlying stands occur on granitoid substrates in the south-west hinterland near Mt Waalimma and Mt Poole. Where Hinterland Wet Shrub Forest co-occurs with Hinterland Wet Fern Forest (Map Unit 13), the latter generally occupies more mesic sites. Distinguishing features include the dominance of *E. muelleriana*, a more diverse tall shrub stratum and lack of fern swards in the understorey of Hinterland Wet Shrub Forest. Clearing is a potential threat over the 3800 ha of Hinterland Wet Shrub Forest that occurs on private land. Outside reserves, logging in combination with frequent burning may threaten the diversity of the understorey by interrupting life-history processes of woody species. In the most similar assemblage described in East Gippsland (Community 13.1, Forbes et al. 1982), *E. obliqua* is equally as frequent as *E. muelleriana* and neither are as frequent as *E. cypellocarpa*. As well, some understorey differences exist. For example elements common in the Eden assemblage such as *A. cognata* are infrequent in the East Gippsland community.

Species richness: 33 ± 2 (0.04 ha)

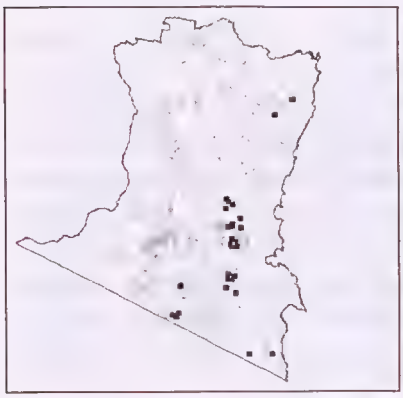
Extant area: 26 169 ha

Proportion cleared: 4%

Number of samples: 36

Table 14a. Diagnostic plant species of Map Unit 14.

Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Acacia cognata	0.639	4(3–4)	0.033	2(1–3)	positive
Acacia maidenii	0.028	3(3–3)	0	0(0–0)	positive
Eucalyptus cypellocarpa	0.917	2(1–3)	0.299	3(2–3)	positive
Eucalyptus muelleriana	0.917	4(3–4)	0.123	3(2–3)	positive
Gonocarpus teucrioides	0.583	2(1–3)	0.309	2(1–2)	positive
Goodenia ovata	0.778	2(1–3)	0.158	2(1–2)	positive
Hibbertia dentata	0.556	2(1–2)	0.063	1(1–2)	positive
Pultenaea flexilis	0.028	2(2–2)	0	0(0–0)	positive
Smilax australis	0.556	2(1–2)	0.194	1(1–2)	positive
Tetrarrhena juncea	0.722	3(2–3)	0.169	2(1–3)	positive
Tylophora barbata	0.778	2(1–2)	0.254	2(1–2)	positive
Viola hederacea subsp. *hederacea*	0.778	2(1–2)	0.429	2(1–2)	positive
Poa meionectes	0.806	2(1–2)	0.532	2(1–3)	frequent
Pteridium esculentum	0.833	2(2–3)	0.57	2(1–3)	frequent
Billardiera scandens	0.722	1(1–2)	0.319	1(1–1)	frequent
Clematis aristata	0.722	1(1–2)	0.332	1(1–1)	frequent
Leucopogon lanceolatus var. *lanceolatus*	0.806	1(1–2)	0.396	1(1–2)	frequent
Lomandra longifolia	0.583	1(1–2)	0.548	2(1–2)	frequent
Acmena smithii	0.083	1(1–2)	0.031	3(1–4)	uninformative
Angophora floribunda	0.028	3(3–3)	0.097	2(1–3)	uninformative
Backhousia myrtifolia	0.028	1(1–1)	0.002	3(1–4)	uninformative
Elaeocarpus reticulatus	0.5	1(1–2)	0.065	1(1–2)	uninformative
Eucalyptus agglomerata	0.028	3(3–3)	0.111	3(2–3)	uninformative
Eucalyptus bosistoana	0.028	2(2–2)	0.054	2(1–3)	uninformative
Eucalyptus botryoides	0.056	2(1–3)	0.01	2(1–3)	uninformative
Eucalyptus elata	0.278	2(1–3)	0.109	3(2–3)	uninformative
Eucalyptus fastigata	0.028	2(2–2)	0.144	3(3–4)	uninformative
Eucalyptus globoidea	0.083	3(1–3)	0.247	3(1–3)	uninformative
Eucalyptus maidenii	0.028	3(3–3)	0.064	3(2–3)	uninformative
Eucalyptus obliqua	0.222	2(1–3)	0.189	3(2–4)	uninformative



Map 14. Distribution of samples of Hinterland Wet Shrub Forest (Map Unit 14) shown by large black squares. Samples of other map units shown as small grey points.

Plate 14. Hinterland Wet Shrub Forest (Map Unit 14) dominated by *Eucalyptus muelleriana*, *E. cypellocarpa* and *E. elata* with *Acacia falciformis*, *A. mearnsii*, *Elaeocarpus reticulatus* and *Cyathea australis* at Knights Creek crossing on Lizards Road, Murrah State Forest.

Eucalyptus radiata	0.028	1(1–1)	0.078	3(1–3)	uninformative
Eucalyptus sieberi	0.389	2(1–3)	0.28	3(2–4)	uninformative
Eucalyptus smithii	0.083	3(1–3)	0.045	2(1–3)	uninformative

Table 14b. Vegetation structure of Map Unit 14. Frequency is the proportion of samples in which strata were present. Height and cover data are means with standard errors in parentheses (n=17).

Stratum	Frequency (%)	Height (m)	Cover (%)
Tree	100	31.9(1.5)	35(2)
Small tree	70.6	9.3(0.9)	30(6)
Shrub	100	3.6(0.6)	30(4)
Ground cover	100	0.8(0.1)	58(6)

Table 14c. Habitat characteristics of Map Unit 14. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5°and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		990	928–1041	36
Altitude (m)		390	318–475	35
Slope (degrees)		16	11–23	31
Terrain class				
North	16			5
Intermediate	26			8
South	45			14
Flat	13			4
Parent material				
Devonian granitoids	25			9
Devonian high quartz sedimentaries	47			17
Low quartz sedimentaries	8			3
Ordovician high quartz sedimentaries	19			7

Map Unit 15: Mountain Wet Herb Forest

Mountain Wet Herb Forest is dominated by *Eucalyptus obliqua* with *E. cypellocarpa* c. 32 m tall. The diverse understorey comprises an open stratum of shrubs up to 2.5 m tall including *Leucopogon lanceolatus* and *Coprosma quadrifida* and a well developed groundcover of herbs, *Dianella tasmanica, Lagenifera stipitata* and *Viola hederacea*, grasses and graminoids, *Hierochloe rariflora, Lomandra longifolia* and *Poa meionectes* with scattered ferns *Pteridium esculentum* and vines of *Clematis aristata*. Mountain Wet Herb Forest is widespread in large stands on moist sheltered granitoid slopes above 500 m elevation on the tableland range south from the upper Tantawangalo Creek catchment. The abundance of *E. obliqua* and prevalence of herbs in a mixed understorey with ferns and shrubs distinguish Mountain Wet Herb Forest from other wet forest assemblages. Approximately one-quarter of this extensive unit has been cleared for pine plantations in the upper Genoa River area and a further 3800 ha are potentially threatened by clearing on private land. Outside reserves, logging in combination with frequent burning may threaten the diversity of the understorey by interrupting life-history processes of woody species. Nevertheless, large stands of Mountain Wet Herb Forest are protected from these disturbance regimes in reserves. Although unlikely to extend further north of the Eden region, a similar assemblage which has a greater abundance

of tall shrubs has been described in East Gippsland (Community 8.2, Forbes et al. 1982) within the extensive wet forest complex (Ecological vegetation Class 30, Woodgate et al. 1994).

Species richness: 33 ± 1 (0.04 ha)

Extant area: 30 895 ha

Proportion cleared: 26%

Number of samples: 132

Table 15a. Diagnostic plant species of Map Unit 15.

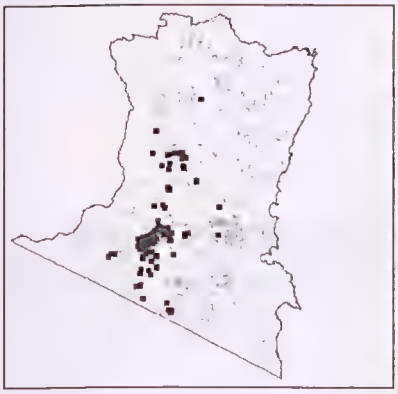
Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Caladenia dilatata	0.008	1(1–1)	0	0(0–0)	positive
Daviesia virgata	0.008	1(1–1)	0	0(0–0)	positive
Dianella tasmanica	0.697	2(1–2)	0.19	1(1–2)	positive
Eucalyptus cypellocarpa	0.803	3(3–3)	0.266	3(1–3)	positive
Eucalyptus obliqua	0.886	3(3–4)	0.121	3(1–3)	positive
Hierochloe rariflora	0.599	3(2–3)	0.141	2(1–3)	positive
Juncus sandwithii	0.008	1(1–1)	0	0(0–0)	positive
Lagenifera stipitata	0.705	2(1–2)	0.287	1(1–2)	positive
Leucopogon lanceolatus var. *lanceolatus*	0.902	2(1–2)	0.357	1(1–2)	positive
Podolepis jaceoides	0.008	2(2–2)	0	0(0–0)	positive
Viola hederacea subsp. *hederacea*	0.955	2(1–2)	0.387	2(1–2)	positive
Lomandra longifolia	0.818	2(1–2)	0.522	2(1–2)	frequent
Poa meionectes	0.932	2(2–3)	0.5	2(1–3)	frequent
Pteridium esculentum	0.947	3(2–3)	0.54	2(1–3)	frequent
Clematis aristata	0.712	1(1–1)	0.305	1(1–1)	frequent
Coprosma quadrifida	0.621	1(1–2)	0.209	1(1–2)	frequent
Acacia melanoxylon	0.106	1(1–2)	0.105	1(1–3)	uninformative
Eucalyptus angophoroides	0.015	1.5(1–2)	0.047	2(1–3)	uninformative
Eucalyptus dalrympleana subsp. *dalrympleana*	0.008	3(3–3)	0.019	2.5(1–3)	uninformative
Eucalyptus dives	0.008	1(1–1)	0.011	3(2–3)	uninformative
Eucalyptus elata	0.144	3(2–3)	0.11	3(2–3)	uninformative
Eucalyptus fastigata	0.205	2(1–3)	0.134	4(3–4)	uninformative
Eucalyptus fraxinoides	0.045	3(3–4)	0.027	4(3–4)	uninformative
Eucalyptus globoidea	0.318	2(1–3)	0.235	3(1–3)	uninformative
Eucalyptus maidenii	0.008	3(3–3)	0.069	3(2–3)	uninformative
Eucalyptus muelleriana	0.038	3(1–3)	0.152	3(2–4)	uninformative
Eucalyptus nitens	0.015	4(4–4)	0.012	3.5(3–4)	uninformative
Eucalyptus radiata	0.152	3(1–3)	0.069	3(1–3)	uninformative
Eucalyptus sieberi	0.318	2(1–3)	0.279	3(2–4)	uninformative
Eucalyptus smithii	0.023	3(3–4)	0.048	2(1–3)	uninformative
Eucalyptus sp. aff. *radiata*	0.121	3(2–4)	0.027	3(1–3)	uninformative
Eucalyptus viminalis	0.015	2(1–3)	0.061	3(1–3)	uninformative

Table 15b. Vegetation structure of Map Unit 15. Frequency is the proportion of samples in which strata were present. Height and cover data are means with standard errors in parentheses (n=97).

Stratum	Frequency (%)	Height (m)	Cover (%)
Tree	100	32.3(0.6)	42(1)
Small tree	44.3	8.1(0.7)	20(2)
Shrub	99	2.4(0.1)	24(2)
Ground cover	100	0.7(0.0)	46(3)

Table 15c. Habitat characteristics of Map Unit 15. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5°and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		1031	990–1061	132
Altitude (m)		736	608–850	132
Slope (degrees)		12	4–20	125
Terrain class				
North	8			10
Intermediate	36			44
South	30			37
Flat	26			32
Parent material				
Devonian granitoids	89			117
Devonian high quartz sedimentaries	3			4
Low quartz sedimentaries	2			3
Ordovician high quartz sedimentaries	5			7
Tertiary Basalt	1			1



Map 15. Distribution of samples of Mountain Wet Herb Forest (Map Unit 15) shown by large black squares. Samples of other map units shown as small grey points.

Plate 15. Mountain Wet Herb Forest (Map Unit 15) dominated by *Eucalyptus obliqua* and *E. cypellocarpa* with scattered *Calochlaena dubia, Doodia aspera* and forbs on the watershed between Wog Wog River and Basin Creek, Coolangubra section of South East Forests National Park.

Map Unit 16: Basalt Wet Herb Forest

Basalt Wet Herb Forest is dominated by *Eucalyptus fastigata* with less frequent trees such as *E. cypellocarpa, E. radiata* and *E. viminalis* c. 30 m tall. There is a sparse stratum of shrubs comprised of infrequent species such as *Acacia melanoxylon*, sometimes growing as small trees to 7 m tall. The groundcover comprises a diverse, almost continuous cover of herbs including *Acaena nova-zelandiae, Asperula scoparia, Dianella tasmanica, Geranium potentilloides, Gonocarpus tetragynus, Hydrocotyle laxiflora, Stellaria pungens* and *Viola hederacea.* These and other small herbs are interspersed among clumps of *Lomandra longifolia, Poa meionectes* and *Pteridium esculentum* and trailing vines of *Glycine clandestina* and *Clematis aristata.* Basalt Wet Herb Forest occurs on gentle slopes on the edge of the tableland, usually at elevations above 700 m on either

basalt or granitoid substrates. In higher rainfall areas close to the escarpment *E. fastigata* predominates, while *E. radiata* and *E. viminalis* are more common in drier areas further west. With decreasing rainfall Basalt Wet Herb Forest grades into Monaro Basalt Grass Woodland (Map Unit 23A). The diverse and dense herbaceous groundcover distinguishes this assemblage from other wet forests on the tableland range. One-sixth of Basalt Wet Herb Forest has been cleared and almost half of the remainder is on private land and potentially threatened by further clearing. Areas of this forest subject to grazing may be exposed to weed invasion and loss of diversity in the species-rich ground stratum. Stands in conservation reserves and State Forests are less exposed to these threats, although some weed invasion has followed logging of stands in western parts of Glenbog State Forest. A restricted assemblage on granitoid substrates on Erinundra Plateau in East Gippsland shares a similarly rich herbaceous groundcover and is dominated by *E. viminalis* and *E. radiata* (Community 8.4, Forbes et al. 1982). Similar assemblages are not known on basalt outside the Eden region, but forests on basalt have been extensively cleared for agriculture wherever they occur in eastern Australia. In East Gippsland, a very restricted forest community on basalt at 450 m elevation near Orbost is dominated by *E. pseudoglobulus* and *E. muelleriana* (Basaltic Damp Forest, Woodgate et al. 1994). Other examples of herb-rich forest on basalt also differ in composition (Ecological Vegetation Class 23, Woodgate et al. 1994).

Species richness: 35 ± 1 (0.04 ha)

Extant area: 12 263 ha

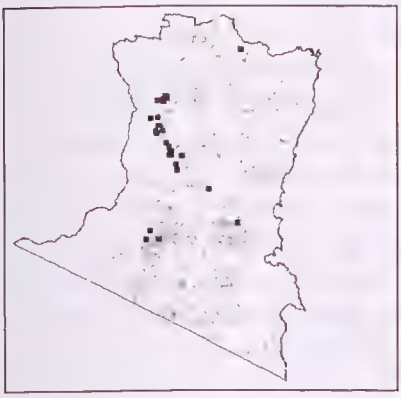
Proportion cleared: 18%

Number of samples: 32

Table 16a. Diagnostic plant species of Map Unit 16.

Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Acaena novae-zelandiae	0.75	2(1–2)	0.118	1(1–2)	positive
Asperula scoparia	0.688	2(1–2)	0.055	1(1–2)	positive
Baumea gunnii	0.031	1(1–1)	0	0(0–0)	positive
Notodanthonia nudiflora	0.031	1(1–1)	0	0(0–0)	positive
Dianella tasmanica	0.906	2(2–3)	0.22	1(1–2)	positive
Eucalyptus fastigata	0.688	3(3–4)	0.129	3(3–4)	positive
Geranium potentilloides	0.563	2(1–2)	0.208	1(1–2)	positive
Glycine clandestina	0.594	2(1–2)	0.322	1(1–2)	positive
Gonocarpus tetragynus	0.656	2(1–2)	0.155	2(1–2)	positive
Hydrocotyle laxiflora	0.563	2(1–2)	0.198	2(1–2)	positive
Luzula densiflora	0.031	1(1–1)	0	0(0–0)	positive
Stellaria pungens	0.5	2(2–2)	0.058	1(1–2)	positive
Viola hederacea subsp. *hederacea*	0.938	2(2–2)	0.426	2(1–2)	positive
Lomandra longifolia	0.656	2(2–2)	0.547	2(1–2)	frequent
Poa meionectes	0.938	3(3–4)	0.53	2(1–3)	frequent
Pteridium esculentum	0.906	3(2–4)	0.569	2(1–3)	frequent
Clematis aristata	0.906	1(1–2)	0.329	1(1–1)	frequent
Lagenifera stipitata	0.719	1(1–2)	0.315	1(1–2)	frequent
Microlaena stipoides var. *stipoides*	0.656	1(1–2)	0.347	2(1–2)	frequent
Veronica calycina	0.781	1(1–1)	0.192	1(1–1)	frequent
Acacia melanoxylon	0.125	2.5(1–3)	0.105	1(1–3)	uninformative

Elaeocarpus holopetalus	0.031	1(1–1)	0.019	1(1–3)	uninformative
Eucalyptus badjensis	0.063	2(1–3)	0.006	3(3–4)	uninformative
Eucalyptus bosistoana	0.063	3.5(3–4)	0.053	2(1–3)	uninformative
Eucalyptus cypellocarpa	0.438	3.5(3–4)	0.311	3(2–3)	uninformative
Eucalyptus dalrympleana subsp. *dalrympleana*	0.156	2(1–3)	0.015	3(1–3)	uninformative
Eucalyptus elata	0.063	2.5(2–3)	0.114	3(2–3)	uninformative
Eucalyptus nitens	0.094	1(1–3)	0.01	4(3–4)	uninformative
Eucalyptus obliqua	0.25	3(2–4)	0.188	3(2–4)	uninformative
Eucalyptus pauciflora	0.063	2(1–3)	0.022	2(1–3)	uninformative
Eucalyptus radiata	0.313	2.5(2–3)	0.072	3(1–3)	uninformative
Eucalyptus rubida	0.063	1(1–1)	0.006	1(1–3)	uninformative
Eucalyptus smithii	0.031	1(1–1)	0.046	2(1–3)	uninformative
Eucalyptus viminalis	0.219	3(1–3)	0.053	3(1–3)	uninformative



Map 16. Distribution of samples of Basalt Wet Herb Forest (Map Unit 16) shown by large black squares. Samples of other map units shown as small grey points.

Plate 16. Basalt Wet Herb Forest (Map Unit 16) dominated by *Eucalyptus viminalis* and *E. fastigata* with a continuous groundcover of *Poa ensiformis, Dianella tasmanica* and *Polystichum proliferum* near Bull Mountain, Tantawangalo section of South East Forests National Park.

Table 16b. Vegetation structure of Map Unit 16. Frequency is the proportion of samples in which strata were present. Height and cover data are means with standard errors in parentheses (n=21).

Stratum	Frequency (%)	Height (m)	Cover (%)
Tree	100	30.5(1.3)	38(4)
Small tree	47.6	7.4(0.8)	25(4)
Shrub	100	2.2(0.2)	12(2)
Ground cover	100	0.6(0.1)	73(5)

Table 16c. Habitat characteristics of Map Unit 16. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5°and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		929	891–954	32
Altitude (m)		915	848–1070	31
Slope (degrees)		9	4–14	31

	Frequency (%)	Mean	Interquartile Range	n
Terrain class				
North	16			5
Intermediate	32			10
South	23			7
Flat	29			9
Parent material				
Devonian Basalt	3			1
Devonian granitoids	56			18
Low quartz sedimentaries	3			1
Tertiary Basalt	38			12

Map Unit 17: Flats Wet Herb Forest

Flats Wet Herb Forest is a very species-rich assemblage dominated by *Eucalyptus viminalis* with less frequent trees including *E. elata* and *E. radiata* over 30 m tall. Scattered small trees or shrubs of *Acacia dealbata, A. melanoxylon, Cassinia aculeata, Pomaderris aspera, Senecio linearifolius* and *Pimelea axiflora* 3–17 m tall overtop a continuous and diverse groundcover comprising herbs *Acaena nova-zelandiae, Geranium potentilloides, Gonocarpus tetragynus, Hydrocotyle laxiflora, Stellaria* spp. and *Viola hederacea,* ferns *Blechnum nudum* and *Pteridium esculentum,* and grasses and graminoids *Carex appressa, Lomandra longifolia* and *Poa meionectes.* Flats Wet Herb Forest occupies gentle granitoid slopes (typically < 5°) in open valleys, usually around low-order drainage lines. Individual stands are comparatively small because of their topographically restricted habitat, and occur in dry, low-relief, low-rainfall areas to the east and west of the escarpment range. Approximately one-sixth of its extent has been cleared for pastoralism and half of the remainder occurs on private land or State Forest under grazing lease. Their gentle topography and comparatively rich deep soils predispose these stands to clearing and/or loss of groundcover diversity through grazing and weed invasion. Sedimentation associated with logging and feral pig rooting also pose threats to soils and the rich ground flora. While analogous habitats

Map 17. Distribution of samples of Flats Wet Herb Forest (Map Unit 17) shown by large black squares. Samples of other map units shown as small grey points.

Plate 17. Flats Wet Herb Forest (Map Unit 17) dominated by *Eucalyptus viminalis* with *Acacia dealbata* (flowering) and a continuous groundcover of *Pteridium esculentum, Poa labillardieri* and *Gahnia sieberi* near Waratah Creek, Coolangubra section of South East Forests National Park.

exist in East Gippsland, the majority of these apparently do not support similar species assemblages. Forbes et al. (1982) described a potentially similar stand beside the Genoa River at Wangarabell (part of Community 13.3). However, dry fertile colluvial flats in East Gippsland typically support herb-rich forest dominated by *E. melliodora, E. angophoroides, E. bosistoana* and *E. pseudoglobulus* in various combinations with qualitatively different shrub and groundcover species (Ecological Vegetation Class 23, Woodgate et al. 1994).

Species richness: 43 ± 3 (0.04 ha)

Extant area: 2949 ha

Proportion cleared: 17%

Number of samples: 19

Table 17a. Diagnostic plant species of Map Unit 17.

Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Acacia dealbata	0.684	3(2–3)	0.131	2(1–3)	positive
Acaena novae–zelandiae	0.684	2(1–2)	0.125	1(1–2)	positive
Blechnum nudum	0.684	2(2–3)	0.072	2(1–4)	positive
Carex appressa	0.737	2(1–2)	0.076	1(1–2)	positive
Carex polyantha	0.053	2(2–2)	0	0(0–0)	positive
Cassinia aculeata	0.526	2(2–3)	0.158	1(1–2)	positive
Eucalyptus viminalis	0.79	3(3–3)	0.047	3(1–3)	positive
Geranium potentilloides	0.895	2(2–2)	0.207	1(1–2)	positive
Juncus pallidus	0.105	2(1–3)	0	0(0–0)	positive
Phebalium squameum	0.053	1(1–1)	0	0(0–0)	positive
Pimelea axiflora	0.526	2.5(2–3)	0.114	1(1–2)	positive
Podolepis hieracioides	0.053	2(2–2)	0	0(0–0)	positive
Pomaderris aspera	0.579	2(2–3)	0.156	2(1–3)	positive
Senecio linearifolius	0.684	2(1–4)	0.234	1(1–2)	positive
Stellaria flaccida	0.684	2(1–2)	0.205	1(1–2)	positive
Stellaria pungens	0.842	2(1–3)	0.057	1(1–2)	positive
Viola hederacea subsp. *hederacea*	0.737	2(2–2)	0.434	2(1–2)	positive
Lomandra longifolia	0.842	2(1–4)	0.545	2(1–2)	frequent
Poa meionectes	0.737	2(2–4)	0.536	2(1–3)	frequent
Pteridium esculentum	0.895	2(2–4)	0.573	2(1–3)	frequent
Lagenifera stipitata	0.632	1(1–2)	0.32	1(1–2)	frequent
Rubus parvifolius	0.632	1(1–2)	0.134	1(1–2)	frequent
Acacia melanoxylon	0.526	1.5(1–3)	0.1	1(1–3)	uninformative
Eucalyptus agglomerata	0.105	1.5(1–2)	0.109	3(2–3)	uninformative
Eucalyptus angophoroides	0.158	1(1–2)	0.043	2(1–3)	uninformative
Eucalyptus bosistoana	0.053	2(2–2)	0.053	2(1–3)	uninformative
Eucalyptus cypellocarpa	0.053	2(2–2)	0.317	3(2–3)	uninformative
Eucalyptus dalrympleana subsp. *dalrympleana*	0.105	1(1–1)	0.017	3(1–3)	uninformative
Eucalyptus elata	0.421	3(3–4)	0.109	3(1–3)	uninformative
Eucalyptus fastigata	0.158	1(1–1)	0.14	3(3–4)	uninformative
Eucalyptus maidenii	0.158	1(1–3)	0.062	3(3–3)	uninformative
Eucalyptus obliqua	0.263	1(1–2)	0.189	3(2–4)	uninformative
Eucalyptus ovata	0.105	2.5(2–3)	0.022	3(1–3)	uninformative
Eucalyptus pauciflora	0.053	1(1–1)	0.023	2(1–3)	uninformative
Eucalyptus polyanthemos subsp. *vestita*	0.053	2(2–2)	0.012	2.5(2–3)	uninformative
Eucalyptus radiata	0.263	3(3–3)	0.074	3(1–3)	uninformative
Eucalyptus sp. aff. *radiata*	0.211	2(1–4)	0.033	3(2–3)	uninformative

Table 17b. Vegetation structure of Map Unit 17. Frequency is the proportion of samples in which strata were present. Height and cover data are means with standard errors in parentheses (n=13).

Stratum	Frequency (%)	Height (m)	Cover (%)
Tree	92.3	31.8(1.3)	34(2)
Small tree	76.9	12.5(2.1)	15(4)
Shrub	92.3	3.0(0.5)	33(6)
Ground cover	100	0.9(0.1)	76(5)

Table 17c. Habitat characteristics of Map Unit 17. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5°and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		912	896–951	19
Altitude (m)		518	425–558	19
Slope (degrees)		4	0–3	19
Terrain class				
North	0			0
Intermediate	11			2
South	5			1
Flat	84			16
Parent material				
Devonian granitoids	95			18
Ordovician high quartz sedimentaries	5			1

Map Unit 18: Brogo Wet Vine Forest

Brogo Wet Vine Forest is dominated by *Eucalyptus tereticornis* with less frequent occurrences of *E. bosistoana* and *E. baueriana* c. 20 m tall, and occasional rainforest elements such as *Alectryon subcinereus* and *Ficus rubiginosa* up to 10 m tall. There is a diverse open stratum of shrubs including *Acacia implexa, Cassinia trinerva, Deeringia amaranthoides, Hymenanthera dentata* and *Breynia oblongifolia*. The species-rich groundcover is composed of large forbs such as *Sigesbeckia orientalis* and *Urtica incisa*, emerging from a diverse matrix of smaller forbs including *Dichondra repens, Geranium solanderi, Hydrocotyle laxiflora, Stellaria flaccida* and others. The groundcover also includes small ferns *Asplenium flabellifolium* and *Pellaea falcata*, and grasses and graminoids, *Oplismenus imbecillus, Microlaena stipoides, Carex appressa, Echinopogon ovatus* and *Poa labillardieri*. *Cenchrus caliculatus* is an infrequent but distinctive grass of this assemblage. A diverse array of vines and twiners is interspersed amongst the groundcover and shrub stratum. These include *Marsdenia rostrata, Clematis glycinoides, Geitonoplesium cymosum, Glycine clandestina* and *Stephania japonica*. Brogo Wet Vine Forest occurs on steep hilly terrain in the Brogo-Bega area at 100–300 m elevation, usually on granitoid substrates, but sometimes on outcrops of Ordovician mudstones near Bega. There are also stands in the Candelo–Myrtle Mountain area. This diverse assemblage is part of a complex of grassy ecosystems (Map Units 18–21) in the Bega valley and associated rainshadow areas. Occurring in the most elevated and wettest parts of the valley, it is distinguished from other assemblages by the dominance of *E. tereticornis* and the abundance of mesophyll shrubs and vines in the understorey. No similar assemblages have been described in adjacent regions (Austin 1978, Woodgate

et al. 1994). Nearly half of this map unit has been cleared for agriculture and just under three-quarters of the remainder occurs on private land where is it potentially threatened by further clearing, grazing and weed invasion (Keith 1995). Frequent fire regimes as part of grazing management and hazard reduction also pose a potential threat, particularly to woody rainforest elements. Substantial areas of Brogo Wet Vine Forest remain in good condition, although remaining stands show symptoms of fine-scale clearing and grazing relative to other grassy assemblages in the Bega valley.

Species richness: 42 ± 2 (0.04 ha)

Extant area: 5046 ha

Proportion cleared: 42%

Number of samples: 16

Table 18a. Diagnostic plant species of Map Unit 18.

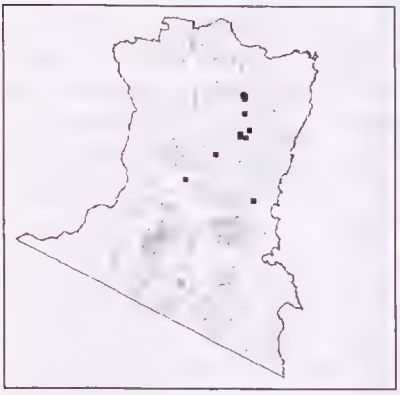
Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Acacia implexa	0.875	2(1–3)	0.042	1(1–2)	positive
Asplenium flabellifolium	0.563	2(1–2)	0.117	1(1–2)	positive
Cassinia trinerva	0.563	2(1–3)	0.078	1(1–3)	positive
Cissus antarctica	0.063	2(2–2)	0	0(0–0)	positive
Davallia pyxidata	0.063	1(1–1)	0	0(0–0)	positive
Deeringia amaranthoides	0.313	1(1–2)	0	0(0–0)	positive
Dichondra repens	1	2(2–2)	0.276	1(1–2)	positive
Eucalyptus tereticornis	0.625	3(3–3)	0.041	3(1–3)	positive
Geranium solanderi	0.938	2(1–2)	0.084	1(1–2)	positive
Hydrocotyle laxiflora	0.688	2(1–2)	0.201	2(1–2)	positive
Hymenanthera dentata	1	3(2–3)	0.06	1(1–2)	positive
Marsdenia rostrata	0.625	2(2–2)	0.08	2(1–2)	positive
Microlaena stipoides var. *stipoides*	0.938	3(2–4)	0.348	1(1–2)	positive
Oplismenus imbecillis	0.875	2(2–3)	0.1	2(1–2)	positive
Pellaea falcata var. *falcata*	1	2(2–3)	0.088	1(1–2)	positive
Sigesbeckia orientalis	0.813	2(1–2)	0.07	1(1–1)	positive
Stellaria flaccida	0.875	2(1–3)	0.204	1(1–2)	positive
Urtica incisa	0.875	2(2–3)	0.06	1(1–1)	positive
Breynia oblongifolia	0.75	1(1–2)	0.023	1(1–1)	frequent
Carex appressa	0.625	1(1–2)	0.078	1(1–2)	frequent
Clematis glycinoides	0.813	1(1–2)	0.108	1(1–2)	frequent
Desmodium varians	0.625	1.5(1–2)	0.246	1(1–2)	frequent
Echinopogon ovatus	0.688	1(1–2)	0.159	1(1–2)	frequent
Geitonoplesium cymosum	0.813	1(1–1)	0.102	1(1–2)	frequent
Glycine clandestina	0.875	1(1–2)	0.321	1(1–2)	frequent
Poa labillardieri var. *labillardieri*	0.625	1(1–3)	0.164	2(1–2)	frequent
Rubus parvifolius	0.75	1(1–2)	0.133	1(1–2)	frequent
Stephania japonica var. *discolor*	0.75	1.5(1–2)	0.017	1(1–1)	frequent
Acacia subporosa	0.063	2(2–2)	0.004	1.5(1–2)	uninformative
Acmena smithii	0.188	1(1–2)	0.03	3(1–4)	uninformative
Alectryon subcinereus	0.188	1(1–3)	0.005	1(1–2)	uninformative
Angophora floribunda	0.375	1(1–2)	0.092	2(1–3)	uninformative
Eucalyptus baueriana	0.063	1(1–1)	0.026	2(1–3)	uninformative
Eucalyptus bosistoana	0.375	2(1–3)	0.049	2(1–3)	uninformative
Eucalyptus globoidea	0.313	3(1–3)	0.242	3(1–3)	uninformative
Ficus rubiginosa	0.188	2(1–5)	0.008	4(1–6)	uninformative
Lomandra longifolia	0.188	1(1–2)	0.553	2(1–2)	negative
Poa meionectes	0	0(1–0)	0.545	2(1–3)	negative
Pteridium esculentum	0.313	2(1–2)	0.58	2(1–3)	negative

Table 18b. Vegetation structure of Map Unit 18. Frequency is the proportion of samples in which strata were present. Height and cover data are means with standard errors in parentheses (n=16).

Stratum	Frequency (%)	Height (m)	Cover (%)
Tree	93.8	20.9(2.0)	21(5)
Small tree	81.3	10.7(1.1)	27(6)
Shrub	100	2.3(0.2)	24(6)
Ground cover	100	0.5(0.1)	56(6)

Table 18c. Habitat characteristics of Map Unit 18. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5° and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		934	886–989	16
Altitude (m)		216	193–245	16
Slope (degrees)		23	20–27	16
Terrain class				
North	44			7
Intermediate	31			5
South	25			4
Flat	0			0
Parent material				
Devonian granitoids	75			12
Devonian high quartz sedimentaries	6			1
Ordovician high quartz sedimentaries	19			3



Map 18. Distribution of samples of Brogo Wet Vine Forest (Map Unit 18) shown by large black squares. Samples of other map units shown as small grey points.

Plate 18. Brogo Wet Vine Forest (Map Unit 18) dominated by *Eucalyptus tereticornis, E. bosistoana* and *E. maidenii* with scattered *Hymenanthera dentata, Pittosporum undulatum* and *Ficus rubiginosa* on Warrigal Range Bush Heritage Property, north of Brogo.

Map Unit 19: Bega Wet Shrub Forest

Bega Wet Shrub Forest is a very species-rich assemblage dominated by *Eucalyptus elata* c. 25 m tall, with less frequent occurrences of *E. baueriana, E. globoidea* and *Angophora floribunda.* Intergrades of *E. botryoides* and *E. saligna* occur in the Cobargo district. *Acacia mearnsii* dominates a small tree stratum c. 10 m tall. The shrub stratum up to

3 m tall is dominated by *Cassinia trinerva* and *Hymenanthera dentata*. The diverse and largely continuous groundcover is composed of small forbs including *Desmodium varians, Dichondra repens, Hydrocotyle laxiflora, Stellaria flaccida, Galium propinquum, Gnaphalium gymnocephalum, Oxalis* spp., *Plantago debilis* and others. The groundcover also includes ferns *Adiantum aethiopicum, Pellaea falcata* and *Pteridium esculentum,* and grasses *Oplismenus imbecillus, Microlaena stipoides, Echinopogon ovatus* and *Poa meionectes,* and graminoids and lilioids *Lomandra longifolia* and *Arthropodium milleflorum. Rubus parvifolius, Clematis glycinoides* and *Glycine clandestina* twine amongst the groundcover. Bega Wet Shrub Forest occurs in dry lowland valleys between Cobargo and Towamba on sheltered slopes and in gullies up to 250 m elevation on Ordovician mudstone or granitoid substrates. This assemblage varies considerably in composition across its range, possibly in relation to soils. For example, an unusual variant dominated by *E. tereticornis* occurs on lowland Devonian basalts in the Wolumla-Nethercote area. Bega Wet Shrub Forest belongs to the complex of grassy ecosystems (Map Units 18–21) in the Bega valley and associated rainshadow areas. Occurring in the most sheltered parts of the valleys, it is distinguished from other assemblages by the dominance of *E. elata* and its prominent small tree and shrub strata. The existence of a similar assemblage in East Gippsland seems doubtful. A single sample of Bega Wet Shrub Forest at south Nungatta near the Victorian border suggests possible affinities to the depleted forests of the lower Cann and Genoa valleys. Woodgate et al (1994) include forest with *E. baueriana* and *E. bosistoana* on flats of the Cann and Genoa River valleys, which are now largely cleared, within Riparian Forest (Ecological Vegetation Class 18) along with other more widespread types of wet forest more closely resembling hinterland wet forests in Eden (Map Units 13 & 14). To the north, similar vegetation occurs in the Yowrie–Wandella area, e.g. at Dignams Creek (CSIRO 1996). Two-thirds of Bega Wet Shrub Forest has been cleared for agriculture and three-quarters of the remainder occurs on private land where is it potentially threatened by further clearing, grazing and weed invasion (Keith 1995). Frequent fire implemented for hazard reduction and grazing management also pose a potential threat, especially to woody components of the community.

Species richness: 48 ± 2 (0.04 ha)
Extant area: 17 959 ha
Proportion cleared: 63%
Number of samples: 38

Table 19a. Diagnostic plant species of Map Unit 19.

Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Acacia mearnsii	0.895	3(1–3)	0.144	2(1–3)	positive
Adiantum aethiopicum	0.553	2(1–2)	0.065	1(1–2)	positive
Cassinia trinerva	0.605	2(1–3)	0.07	1(1–2)	positive
Clematis glycinoides	0.684	2(1–2)	0.1	1(1–1)	positive
Cyperus sphaeroideus	0.026	1(1–1)	0	0(0–0)	positive
Desmodium varians	0.842	2(1–2)	0.234	1(1–2)	positive
Dichondra repens	0.868	2(2–2)	0.269	1(1–2)	positive
Eucalyptus elata	0.605	3(1–4)	0.1	3(2–3)	positive
Geranium retrorsum	0.053	1(1–1)	0	0(0–0)	positive
Glycine clandestina	0.947	2(1–2)	0.311	1(1–2)	positive

Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Hydrocotyle laxiflora	0.868	2(2–2)	0.188	1(1–2)	positive
Mentha satureioides	0.053	1.5(1–2)	0	0(0–0)	positive
Microlaena stipoides var. *stipoides*	0.947	2(2–3)	0.338	1(1–2)	positive
Oplismenus imbecillis	0.737	2(1–3)	0.092	2(1–2)	positive
Oxalis chnoodes	0.026	1(1–1)	0	0(0–0)	positive
Oxalis rubens	0.026	1(1–1)	0	0(0–0)	positive
Paspalum orbiculare	0.026	1(1–1)	0	0(0–0)	positive
Pellaea falcata var. *falcata*	0.632	2(1–3)	0.084	1(1–2)	positive
Stellaria flaccida	0.711	2(1–2)	0.198	1(1–2)	positive
Poa meionectes	0.632	2(1–3)	0.536	2(1–3)	frequent
Pteridium esculentum	0.684	2(1–2)	0.574	2(1–3)	frequent
Arthropodium milleflorum	0.632	1(1–2)	0.048	1(1–1)	frequent
Echinopogon ovatus	0.868	1(1–2)	0.146	1(1–2)	frequent
Galium propinquum	0.658	1(1–1)	0.126	1(1–1)	frequent
Gnaphalium gymnocephalum	0.632	1(1–1)	0.172	1(1–1)	frequent
Hymenanthera dentata	0.658	1(1–3)	0.054	1(1–2)	frequent
Lomandra longifolia	0.763	1(1–2)	0.543	2(1–2)	frequent
Oxalis perennans	0.605	1(1–1)	0.212	1(1–1)	frequent
Plantago debilis	0.605	1(1–2)	0.1	1(1–1)	frequent
Rubus parvifolius	0.79	1(1–2)	0.123	1(1–2)	frequent
Angophora floribunda	0.368	1(1–2)	0.088	2(1–3)	uninformative
Eucalyptus angophoroides	0.158	2(1–3)	0.041	2(1–3)	uninformative
Eucalyptus baueriana	0.368	3(1–4)	0.017	2(1–3)	uninformative
Eucalyptus bosistoana	0.132	1(1–3)	0.051	2(1–3)	uninformative
Eucalyptus botryoides–E. saligna	0.132	3(2–4)	0.008	1(1–2)	uninformative
Eucalyptus cypellocarpa	0.053	3(3–3)	0.321	3(2–3)	uninformative
Eucalyptus globoidea	0.368	1(1–3)	0.239	3(1–3)	uninformative
Eucalyptus maidenii	0.105	3(3–3)	0.062	3(2–3)	uninformative
Eucalyptus melliodora	0.053	1.5(1–2)	0.01	2(1–3)	uninformative
Eucalyptus muelleriana	0.026	2(2–2)	0.145	3(2–4)	uninformative
Eucalyptus ovata	0.026	3(3–3)	0.023	3(1–3)	uninformative
Eucalyptus polyanthemos subsp. *vestita*	0.026	1(1–1)	0.014	2(2–3)	uninformative
Eucalyptus radiata	0.053	2(1–3)	0.077	3(1–3)	uninformative
Eucalyptus sieberi	0.026	1(1–1)	0.289	3(2–4)	uninformative
Eucalyptus tereticornis	0.158	2(1–3)	0.044	3(1–3)	uninformative
Eucalyptus viminalis	0.105	1.5(1–3)	0.056	3(1–3)	uninformative

Table 19b. Vegetation structure of Map Unit 19. Frequency is the proportion of samples in which strata were present. Height and cover data are means with standard errors in parentheses (n=28).

Stratum	Frequency (%)	Height (m)	Cover (%)
Tree	100	24.9(1.0)	25(2)
Small tree	96.4	9.3(0.7)	19(3)
Shrub	96.4	2.6(0.2)	25(5)
Ground cover	100	0.4(0.1)	68(5)

Table 19c. Habitat characteristics of Map Unit 19. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5° and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		884	832–955	38
Altitude (m)		193	129–268	38
Slope (degrees)		20	10–24	38
Terrain class				
North	16			6
Intermediate	26			10
South	50			19
Flat	8			3
Parent material				
Devonian granitoids	66			25
Devonian high quartz sedimentaries	3			1
Ordovician high quartz sedimentaries	32			12

Map 19. Distribution of samples of Bega Wet Shrub Forest (Map Unit 19) shown by large black squares. Samples of other map units shown as small grey points.

Plate 19. Bega Wet Shrub Forest (Map Unit 19) dominated by *Eucalyptus baueriana, E. viminalis* and *E. radiata* with a prominent shrub stratum of *Cassinia longifolia* and *Kunzea ericoides,* and groundcover dominated by *Lepidosperma gunnii* near Myrtle Creek, Yowaka section of South East Forests National Park.

Map Unit 20: Bega Dry Grass Forest

Bega Dry Grass Forest is dominated by *Eucalyptus tereticornis* with *E. globoidea* and *Angophora floribunda.* Although extant stands average 20 m in height, these are largely regrowth of originally taller forests. *Acacia mearnsii* dominates an open small tree stratum 9 m tall, while an open shrub stratum includes *Bursaria spinosa* and *Ozothamnus diosmifolius.* The characteristic diverse grassy groundcover is dominated by *Themeda australis, Echinopogon caespitosus, E. ovatus, Microlaena stipoides* and *Eragrostis leptostachya* with forbs such as *Dichondra repens, Desmodium varians, Hydrocotyle laxiflora, Hypericum gramineum, Glycine clandestina* and the fern *Cheilanthes sieberi.* Bega Dry Grass Forest occurs on undulating terrain in the Cobargo–Bega–Candelo area and the Towamba valley below 250 m elevation on

granitoid substrates and Ordovician mudstones. Small stands also occur on fine-grained igneous intrusives on the coast near Tanja. This assemblage is part of a complex of grassy ecosystems (Map Units 18–21) in the Bega valley and associated rainshadow areas. It is distinguished from other assemblages by the dominance of *E. tereticornis* usually with *A. floribunda* and a prominent grassy understorey. Local frost hollows near Wolumla may include *E. pauciflora*. No similar assemblages have been described in adjacent regions (Austin 1978, Woodgate et al. 1994), although stands of *E. tereticornis* occur near Moruya to the north. Nearly 90% of this vegetation has been cleared for agriculture and almost all of the remainder is highly fragmented on private land where is it potentially threatened by further clearing, grazing and weed invasion (Keith 1995).

Species richness: 39 ± 1 (0.04 ha)

Extant area: 4429 ha

Proportion cleared: 86%

Number of samples: 48

Table 20a. Diagnostic plant species of Map Unit 20.

Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Bursaria spinosa	0.604	2(1–3)	0.107	1(1–2)	positive
Dichondra repens	0.979	2(1–2)	0.261	1(1–2)	positive
Echinopogon caespitosus	0.5	2(1–2)	0.024	1(1–1)	positive
Echinopogon ovatus	0.542	2(1–2)	0.152	1(1–2)	positive
Eucalyptus tereticornis	0.521	3(1–3)	0.031	3(1–3)	positive
Glycine sp. aff. *tomentella*	0.063	1(1–1)	0	0(0–0)	positive
Laxmannia gracilis	0.063	1(1–1)	0	0(0–0)	positive
Microlaena stipoides var. *stipoides*	0.979	3(2–4)	0.333	1(1–2)	positive
Polygala japonica	0.021	1(1–1)	0	0(0–0)	positive
Austrostipa densiflora	0.021	2(2–2)	0	0(0–0)	positive
Themeda australis	0.896	3(2–4)	0.088	2(1–3)	positive
Vittadinia dissecta var. *dissecta*	0.021	1(1–1)	0	0(0–0)	positive
Acacia mearnsii	0.667	1(1–3)	0.146	2(1–3)	frequent
Cheilanthes sieberi subsp. *sieberi*	0.75	1(1–2)	0.039	1(1–1)	frequent
Desmodium varians	0.625	1(1–2)	0.237	2(1–2)	frequent
Eragrostis leptostachya	0.667	1(1–2)	0.025	2(1–2)	frequent
Glycine clandestina	0.833	1(1–2)	0.31	1(1–2)	frequent
Hydrocotyle laxiflora	0.792	1.5(1–2)	0.186	2(1–2)	frequent
Hypericum gramineum	0.604	1(1–1)	0.23	1(1–2)	frequent
Ozothamnus diosmifolius	0.708	1(1–2)	0.058	1(1–1)	frequent
Lomandra longifolia	0.75	1(1–1)	0.542	2(1–2)	frequent
Angophora floribunda	0.458	3(1–4)	0.083	2(1–3)	uninformative
Eucalyptus agglomerata	0.042	3(3–3)	0.111	3(2–3)	uninformative
Eucalyptus angophoroides	0.021	1(1–1)	0.045	2(1–3)	uninformative
Eucalyptus baueriana	0.167	1(1–3)	0.022	2(2–3)	uninformative
Eucalyptus bosistoana	0.104	3(2–3)	0.051	2(1–3)	uninformative
Eucalyptus botryoides	0.042	1.5(1–2)	0.011	2(1–3)	uninformative
Eucalyptus dives	0.021	3(3–3)	0.011	3(2–3)	uninformative
Eucalyptus elata	0.208	3(3–4)	0.11	3(1–3)	uninformative
Eucalyptus globoidea	0.438	3(2–4)	0.236	3(1–3)	uninformative
Eucalyptus maidenii	0.042	2(1–3)	0.064	3(2–3)	uninformative
Eucalyptus melliodora	0.042	2(1–3)	0.011	2(1–3)	uninformative

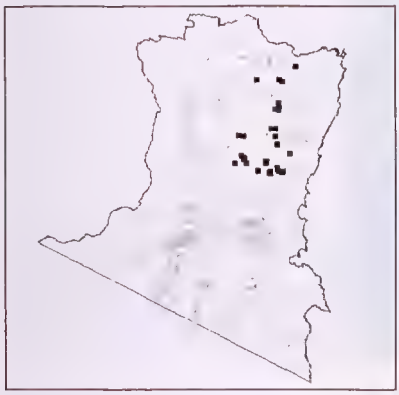
Eucalyptus pauciflora	0.021	1(1–1)	0.023	2(1–3)	uninformative
Eucalyptus polyanthemos subsp. *vestita*	0.021	1(1–1)	0.014	2(2–3)	uninformative
Eucalyptus radiata	0.042	2(1–3)	0.078	3(1–3)	uninformative
Eucalyptus sieberi	0.063	3(1–4)	0.29	3(2–4)	uninformative
Eucalyptus viminalis	0.083	3(2–4)	0.056	3(1–3)	uninformative
Poa meionectes	0.125	1(1–1)	0.553	2(1–3)	negative
Pteridium esculentum	0.25	1(1–2)	0.588	2(1–3)	negative

Table 20b. Vegetation structure of Map Unit 20. Frequency is the proportion of samples in which strata were present. Height and cover data are means with standard errors in parentheses (n=47).

Stratum	Frequency (%)	Height (m)	Cover (%)
Tree	100	21.3(0.7)	23(2)
Small tree	80.9	8.9(0.5)	15(2)
Shrub	97.9	2.4(0.1)	19(2)
Ground cover	100	0.4(0.0)	62(4)

Table 20c. Habitat characteristics of Map Unit 20. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5° and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		822	768–835	48
Altitude (m)		132	99–176	48
Slope (degrees)		14	8–19	48
Terrain class				
North	32			15
Intermediate	47			22
South	17			8
Flat	4			2
Parent material				
Devonian granitoids	33			16
Devonian high quartz sedimentaries	13			6
Ordovician high quartz sedimentaries	54			26



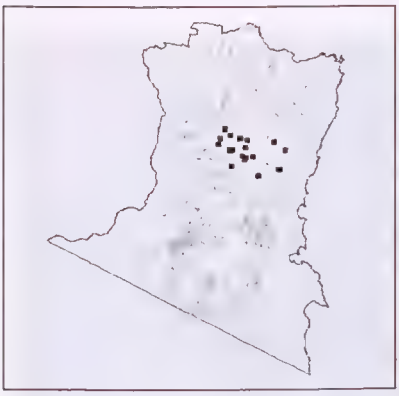
Map 20. Distribution of samples of Bega Dry Grass Forest (Map Unit 20) shown by large black squares. Samples of other map units shown as small grey points.

Plate 20. Bega Dry Grass Forest (Map Unit 20) dominated by *Eucalyptus tereticornis* and occasional *E. baueriana* with *Indigofera australis, Themeda australis* and *Microlaena stipoides* alongside a fenced roadside north of Wolumla, showing the effects of light grazing.

Map Unit 21: Candelo Dry Grass Forest

Candelo Dry Grass Forest is dominated by *Eucalyptus tereticornis, E. globoidea* and *Angophora floribunda,* usually with *E. melliodora* c. 22 m tall. *Acacia mearnsii* is the most frequent species in sparse strata of small trees and shrubs 2–8 m tall. The distinctive and diverse grassy groundcover is dominated by *Themeda australis, Notodanthonia racemosa, Dichanthium sericeum, Eragrostis leptostachya, Microlaena stipoides* and *Dichelachne micrantha,* with forbs including *Dichondra repens, Desmodium varians, Hydrocotyle laxiflora, Geranium solanderi* and *Gnaphalium gymnocephalum. Glycine tabacina* and *G. clandestina* trail amongst the groundcover. Candelo Dry Grass Forest occurs on undulating terrain in the driest western parts of the Bega and Towamba valleys below 300 m elevation on granitoid substrates or rarely Ordovician mudstones. Frost hollows near Candelo support stands of *E. pauciflora,* but these persist only as small highly modified remnants. This assemblage is part of a complex of grassy ecosystems (Map Units 18–21) in the Bega valley and associated rainshadow areas. It is distinguished from other assemblages by the inclusion of *E. melliodora* in the tree stratum and groundcover elements such as *Dichanthium sericeum* and *Glycine tabacina*. It generally grades from west to east into Bega Dry Grass Forest (Map Unit 20), and the precise boundary between these units is somewhat arbitrary, although an outlying stand of Candelo Dry Grass Forest has been recorded between Bega and Wolumla. No similar assemblages have been described in adjacent regions (Austin 1978, Woodgate et al. 1994). Over 90% of this vegetation has been cleared for agriculture and almost all of the remaining 1500 ha is highly fragmented on private land where is it threatened by further clearing, grazing and weed invasion (Keith 1995).

Species richness: 35 ± 3 (0.04 ha)
Extant area: 1571 ha
Proportion cleared: 91%
Number of samples: 28



Map 21. Distribution of samples of Candelo Dry Grass Forest (Map Unit 21) shown by large black squares. Samples of other map units shown as small grey points.

Plate 21. Candelo Dry Grass Forest (Map Unit 21) remnant dominated by *Eucalyptus tereticornis* and *E. melliodora* with a continuous grassy understorey dominated by *Themeda australis* at Bemboka cemetery.

Table 21a. Diagnostic plant species of Map Unit 21.

Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Angophora floribunda	0.679	3(1–4)	0.084	2(1–3)	positive
Brachycome ciliata var. *ciliata*	0.071	1(1–1)	0	0(0–0)	positive
Chloris ventricosa	0.036	2(2–2)	0	0(0–0)	positive
Notodanthonia racemosa var. *racemosa*	0.679	2(1–2)	0.039	1(1–2)	positive
Dichanthium sericeum	0.429	1(1–2)	0	0(0–0)	positive
Dichondra repens	0.893	2(2–3)	0.272	1(1–2)	positive
Eragrostis leptostachya	0.75	2(2–3)	0.033	1(1–2)	positive
Eucalyptus globoidea	0.643	3(1–3)	0.235	3(1–3)	positive
Eucalyptus tereticornis	0.786	3(1–3)	0.033	3(1–3)	positive
Glycine tabacina	0.536	2(1–2)	0.024	1(1–2)	positive
Hydrocotyle laxiflora	0.75	2(1–2)	0.195	2(1–2)	positive
Microlaena stipoides var. *stipoides*	0.857	2(2–3)	0.344	1(1–2)	positive
Plantago hispida	0.036	4(4–4)	0	0(0–0)	positive
Themeda australis	0.821	4(3–4)	0.1	2(1–3)	positive
Zornia dyctiocarpa	0.036	1(1–1)	0	0(0–0)	positive
Acacia mearnsii	0.607	1(1–3)	0.154	2(1–3)	frequent
Desmodium varians	0.679	1(1–2)	0.242	1(1–2)	frequent
Dichelachne micrantha	0.714	1(1–2)	0.073	1(1–2)	frequent
Geranium solanderi	0.714	1(1–2)	0.081	1(1–2)	frequent
Glycine clandestina	0.786	1(1–2)	0.319	1(1–2)	frequent
Gnaphalium gymnocephalum	0.714	1(1–1)	0.173	1(1–1)	frequent
Eucalyptus baueriana	0.036	1(1–1)	0.026	2(1–3)	uninformative
Eucalyptus bosistoana	0.071	1.5(1–2)	0.053	2(1–3)	uninformative
Eucalyptus elata	0.071	1(1–1)	0.114	3(2–3)	uninformative
Eucalyptus maidenii	0.107	3(3–3)	0.062	3(2–3)	uninformative
Eucalyptus melliodora	0.429	1.5(1–3)	0.003	2(1–3)	uninformative
Eucalyptus viminalis	0.036	1(1–1)	0.057	3(1–3)	uninformative
Lomandra longifolia	0.321	1(1–1)	0.553	2(1–2)	negative
Poa meionectes	0.429	1.5(1–3)	0.541	2(1–3)	negative
Pteridium esculentum	0.179	1(1–2)	0.585	2(1–3)	negative

Table 21b. Vegetation structure of Map Unit 21. Frequency is the proportion of samples in which strata were present. Height and cover data are means with standard errors in parentheses (n=28).

Stratum	Frequency (%)	Height (m)	Cover (%)
Tree	100	22.4(0.8)	24(2)
Small tree	50	8.4(0.8)	20(4)
Shrub	89.3	1.9(0.2)	12(3)
Ground cover	100	0.3(0.0)	77(4)

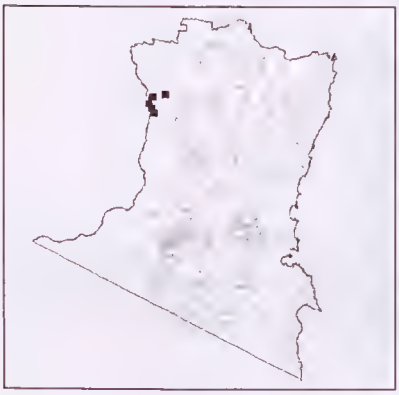
Table 21c. Habitat characteristics of Map Unit 21. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5° and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		792	774–816	28
Altitude (m)		149	105–183	28
Slope (degrees)		14	8–21	28

	Frequency (%)	Mean	Interquartile Range	n
Terrain class				
North	14			4
Intermediate	61			17
South	18			5
Flat	7			2
Parent material				
Devonian granitoids	86			24
Ordovician high quartz sedimentaries	14			4

Map Unit 22A: Monaro Dry Grass Forest

Monaro Dry Grass Forest is dominated by *Eucalyptus pauciflora, E. rubida* and *E. viminalis*. Scattered shrubs of *Acacia dealbata* emerge from a stratum of smaller shrubs, *Bossiaea foliosa, Gompholobium minus* and *Mirbelia oxylobioides* and grassy groundcover dominated by *Themeda australis* and *Poa labillardieri*, with forbs including *Asperula scoparia* and *Gonocarpus tetragynus*. Monaro Dry Grass Forest occurs on flat to undulating terrain in the Monaro rainshadow (< 840 mm annual precipitation) from Bombala north to Numeralla above 900 m elevation on granitoid substrates or rarely fine-grained metasediments. This assemblage is part of a complex of grassy assemblages (Map Units 22–24) on the Monaro Tableland rainshadow area. Similar assemblages are found both to the north and south-west. In East Gippsland near Suggan Buggan, one of two floristic entities within Ecological Vegetation Class 37 (Woodgate et al. 1994, Community 5.3 of Forbes et al. 1982) shares similar canopy and groundcover elements. Similar vegetation also occurs east of Cooma to the north (Austin 1978, CSIRO 1996). Approximately one-third of Monaro Dry Grass Forest has been cleared for agriculture. The remainder occurs almost entirely on private and leasehold where weed invasion and overgrazing in dry periods are likely to cause a decline in groundcover diversity. Further clearing may also pose a significant threat to the 7000 ha that occurs on private land.



Map 22A. Distribution of samples of Monaro Dry Grass Forest (Map Unit 22A) shown by large black squares. Samples of other map units shown as small grey points.

Plate 22A. Monaro Dry Grass Forest (Map Unit 22A) dominated by *Eucalyptus viminalis* with *E. pauciflora* and *E. dives* with a grassy understorey dominated by *Poa meionectes* on New Line Road, Glen Allen State Forest.

Species richness: 16 ± 1 (0.04 ha)
Extant area: 8222 ha
Proportion cleared: 31%
Number of samples: 5

Table 22Aa. Diagnostic plant species of Map Unit 22A.

Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Acacia dealbata	0.6	3(3–3)	0.136	2(1–3)	positive
Asperula scoparia	0.8	2.5(2–3)	0.066	1(1–2)	positive
Bossiaea foliosa	0.6	2(1–3)	0.016	1(1–2)	positive
Dichelachne inaequiglumis	0.2	3(3–3)	0	0(0–0)	positive
Eucalyptus parvula	0.2	1(1–1)	0	0(0–0)	positive
Eucalyptus pauciflora	1	3(1–3)	0.02	2(1–3)	positive
Eucalyptus rubida	0.6	3(1–3)	0.005	1(1–1)	positive
Eucalyptus viminalis	0.6	3(3–3)	0.055	3(1–3)	positive
Gompholobium minus	0.4	1.5(1–2)	0	0(0–0)	positive
Gonocarpus tetragynus	0.6	2(2–2)	0.164	2(1–2)	positive
Mirbelia oxylobioides	0.4	2.5(2–3)	0	0(0–0)	positive
Themeda australis	0.8	2(1–3)	0.112	2(1–3)	positive
Poa labillardieri var. *labillardieri*	0.8	1.5(1–2)	0.167	1(1–3)	frequent
Lomandra longifolia	0.4	1.5(1–2)	0.549	2(1–2)	negative
Poa meionectes	0.2	3(3–3)	0.54	2(1–3)	negative
Pteridium esculentum	0	0(0–0)	0.579	2(1–3)	negative

Table 22Ab. Habitat characteristics of Map Unit 22A. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5° and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		635	711–828	5
Altitude (m)		1084	1080–1120	5
Slope (degrees)		-	-	0
Terrain class				
North	0			0
Intermediate	0			0
South	20			1
Flat	80			4
Parent material				
Devonian granitoids	80			4
Low quartz sedimentaries	20			1

Map Unit 22B: Numeralla Dry Grass Woodland

Numeralla Dry Grass Woodland is dominated by *Eucalyptus dives,* sometimes with *E. dalrympleana* and *E. pauciflora. Eucalyptus mannifera* and *E. rubida* may also be locally common. The tree stratum is low (c. 15 m) and open. The shrub stratum is dominated by *Acacia falciformis, A. dealbata, Exocarpos strictus* and *Gompholobium huegelii.* The groundcover includes scattered tussocks of *Poa meionectes* and *Lomandra longifolia* with large clumps of *Chrysocephalum semipapposum.* and grassy groundcover dominated by *Themeda australis* and *Poa labillardieri,* with forbs including *Asperula scoparia* and *Gonocarpus tetragynus.* Numeralla Dry Grass Woodland occurs on dry

stony ridges in the upper Numeralla and McLaughlan River catchments above 900 m elevation on metasediments. This assemblage is part of a complex of grassy assemblages (Map Units 22–24) on the Monaro Tableland rainshadow area. It differs from other Monaro assemblages in the dominance of *E. dives* and its abundance of shrubs relative to grasses. This assemblage is likely to extend further north, east of Cooma (Costin 1954, Austin 1978, CSIRO 1996). The most similar assemblage in East Gippsland is associated with the Snowy, Deddick and Delegate River gorges and includes additional tree species and a more diverse array of shrubs (Community 5.1 of Forbes et al. 1982, Ecological Vegetation Class 36 of Woodgate et al. 1994). Approximately one-third of Numeralla Dry Grass Woodland has been cleared for agriculture and about one-quarter occurs in a recently dedicated reserve. The remainder occurs mainly on private and leasehold land. Further clearing poses the most significant threat to the 1300 ha that occurs on private land, although these are unlikely to be very productive grazing lands. Rough grazing may cause a decline in groundcover diversity and weed invasion, depending on stocking rates.

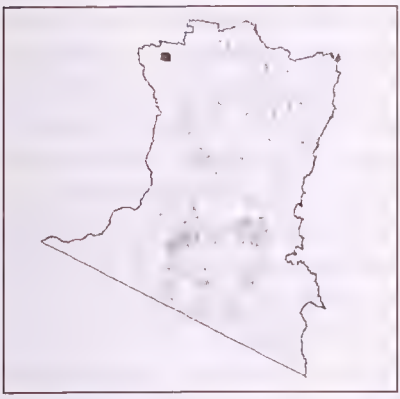
Species richness: 13 ± 3 (0.04 ha)
Extant area: 3611 ha
Proportion cleared: 33%
Number of samples: 3

Table 22Ba. Diagnostic plant species of Map Unit 22B.

Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Acacia falciformis	1	2(2–2)	0.188	2(1–3)	positive
Chrysocephalum semipapposum	1	3(2–3)	0.008	1(1–2)	positive
Eucalyptus dives	1	3(3–3)	0.01	3(2–3)	positive
Exocarpos strictus	0.667	2(2–2)	0.17	1(1–2)	positive
Gompholobium huegelii	0.667	2(2–2)	0.015	1(1–1)	positive
Leucopogon hookeri	0.333	2(2–2)	0	0(0–0)	positive
Persoonia rigida	0.333	2(2–2)	0	0(0–0)	positive
Poa meionectes	1	2(2–3)	0.538	2(1–3)	frequent
Acacia dealbata	0.667	1.5(1–2)	0.137	2(1–3)	frequent
Acaena novae–zelandiae	1	1(1–2)	0.13	1(1–2)	frequent
Lomandra longifolia	1	1(1–2)	0.548	2(1–2)	frequent
Eucalyptus dalrympleana subsp. *dalrympleana*	0.3333	1(1–1)	0.01868	3(1–3)	uninformative
Eucalyptus pauciflora	0.3333	1(1–1)	0.02253	2(1–3)	uninformative
Pteridium esculentum	0	0(2–0)	0.578	2(1–3)	negative

Table 22Bb. Vegetation structure of Map Unit 22B. Frequency is the proportion of samples in which strata were present. Height and cover data are means with standard errors in parentheses (n=3).

Stratum	Frequency (%)	Height (m)	Cover (%)
Tree	100	14.3(0.7)	20(0)
Small tree	33.3	6.0(-)	5(-)
Shrub	100	2.2(0.9)	25(8)
Ground cover	100	0.3(0.1)	20(6)



Map 22B. Distribution of samples of Numeralla Dry Grass Woodland (Map Unit 22B) shown by large black squares. Samples of other map units shown as small grey points.

Plate 22B. Numeralla Dry Grass Woodland (Map Unit 22B) dominated by *Eucalyptus rubida, E. dives* and *E. pauciflora* with *Chrysocephalum semipapposum, Hibbertia obtusifolia, Daviesia corymbosa* and *Grevillea lanigera* on McLaughlin River near Snowy Highway crossing.

Table 22Bc. Habitat characteristics of Map Unit 22B. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5° and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		658	647–677	3
Altitude (m)		1003	970–1050	3
Slope (degrees)		17	11–22	3
Terrain class				
North	0			0
Intermediate	33			1
South	67			2
Flat	0			0
Parent material				
Low quartz sedimentaries	100			3

Map Unit 23A: Monaro Grassland

Monaro Grassland includes several floristic assemblages characteristic of different habitats and disturbance histories. Floristic data recorded in 10 x 10 m quadrats were compiled from Benson (1994) who recognised eight grassland assemblages on the Monaro Tableland, of which three were sampled in the Eden study area. The grasses *Poa sieberiana, Themeda australis* and *P. labillardieri* dominate Benson's communities 4, 5 and 8, respectively. Common interstitial herbs include *Acaena ovina, Geranium antrorsum, Asperula conferta, Chrysocephalum apiculatum, Leptorhychos squamatus, Plantago varia* and *Cullen tenax.* Grassland composition varies within the region according to substrate, soil moisture status and grazing history. Benson (1994) attributed differences in between communities 3 and 4 to differences in grazing pressure, while community 8 was found in low-lying poorly drained sites. Monaro Grassland occurs on heavy textured soils, usually derived from basalt, alluvium or

granitoids above 800 m elevation in a rainshadow characterised by low rainfall (< 800 mm mean annual precipitation), periodic drought, drying summer winds, frosts and cold winter temperatures (Benson 1994). The largest and least disturbed stands occur between Bombala and Nimmitabel. Similar grasslands extend west and north-west on parts of the Monaro Tableland (Costin 1954, Benson 1994) and south into Victoria on the Nunniong High Plains and Emu Flat (Community 7.3, Walsh et al. 1983). However, there are notable differences in composition compared with alpine and subalpine grasslands in the Kosciusko area and Victorian alps and lowland grasslands in Victoria and Tasmania (Benson 1994, McDougall & Kirkpatrick 1993). All Australian temperate grasslands, including those of the Eden region persist in a highly modified, depleted state. Approximately one-twentieth of the region's grassland remains in a semi-natural state, although even this figure may be an overestimate. In the East Gippsland highlands, only 200 ha of degraded grassland remain (Woodgate et al. 1994). Most of the Monaro remnants are also heavily degraded by pasture improvement and overgrazing, although several small but significant patches retain a large complement of native species. These latter patches are associated with cemeteries, church yards, rubbish tips, travelling stock reserves, and other small parcels of land that have been excluded from the most intensive pastoral land management practices. There are currently no formal conservation reserves that contain examples of grassland assemblages in the region and opportunities for conservation on and off reserve are extremely limited. The severity of continuing degradation supports the need for urgent conservation. Clearing and nutrification associated with cropping and pasture improvement encourages the replacement of native species by fast-growing swards of exotic grasses and herbs. Weed invasion associated with nutrification is most pronounced along drainage lines supporting assemblages dominated by *Poa labillardieri* (Benson 1994). Nutrification may also be associated with compositional shifts within the native component of the flora, with *P. labillardieri* known to produce a greater growth response to fertilisers than *Themeda australis* (Groves et al. 1973). High levels of grazing pressure are also associated with compositional changes. Species with erect herbaceous growth forms (e.g. *Microseris lanceolata, Podolepis hieracioides, Bulbine bulbosa, Discaria pubescens*) are likely to be more prone to elimination by intense grazing than those with rosette growth forms, which include several ubiquitous weed species (McIntyre et al. 1995). *Themeda australis* appears to be less resilient to heavy grazing than other grasses (Vickery 1961, Benson 1994). Contemporary disturbance regimes may also be associated with loss of diversity from grasslands, since the persistence of some herbaceous species is known to be dependent on gap dynamics (e.g. Morgan 1997). Disturbance regimes comprising certain mixtures of fire and grazing (e.g. exclusion of fire and herbivores, high stocking rates and fire exclusion) have been implicated in the loss of grassland diversity (Lunt 1991).

Species richness: 11.0 ± 2.5 (0.01ha)
Extant area: 331 ha
Proportion cleared: 94%
Number of samples: 5

Table 23Aa. Diagnostic plant species of Map Unit 23A.

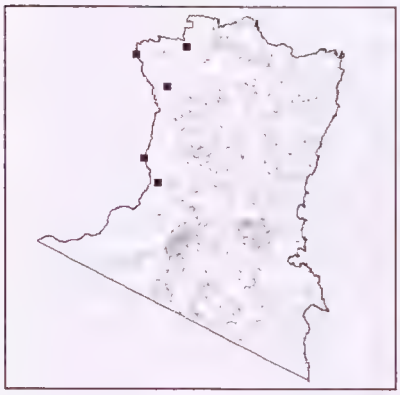
Species	Target frequency	Target C/A	Fidelity class
Poa sieberiana	0.6	3(2–4)	positive
Acaena ovina	0.6	1(1–1)	positive
Poa labillardieri	0.4	5(5–5)	positive
Themeda australis	0.4	4(2–6)	positive
Geranium antrorsum	0.4	2.5(1–4)	positive
Asperula conferta	0.4	2(2–2)	positive
Chrysocephalum apiculatum	0.4	2(2–2)	positive
Leptorhynchos squamatus	0.4	1.5(1–2)	positive
Plantago varia	0.4	1.5(1–2)	positive
Carex inversa	0.4	1(1–1)	positive
Notodanthonia caespitosa	0.4	1(1–1)	positive
Elymus scaber	0.4	1(1–1)	positive
Cullen tenax	0.4	1(1–1)	positive
Pimelea glauca	0.2	3(3–3)	positive
Poa meionectes	0.2	3(3–3)	positive
Bothriochloa macra	0.2	2(2–2)	positive
Carex appressa	0.2	2(2–2)	positive
Notodanthonia monticola	0.2	2(2–2)	positive
Helichrysum scorpioides	0.2	2(2–2)	positive
Juncus filicaulis	0.2	2(2–2)	positive
Schoenus apogon	0.2	2(2–2)	positive
Scleranthus biflorus	0.2	2(2–2)	positive
Scleranthus diander	0.2	2(2–2)	positive
Acaena novae-zelandiae	0.2	1(1–1)	positive
Agrostis avenacea var. *avenacea*	0.2	1(1–1)	positive
Carex longebrachiata	0.2	1(1–1)	positive
Convolvulus erubescens	0.2	1(1–1)	positive
Crassula sieberiana	0.2	1(1–1)	positive
Notodanthonia pilosa var. *pilosa*	0.2	1(1–1)	positive
Desmodium varians	0.2	1(1–1)	positive
Enneapogon nigricans	0.2	1(1–1)	positive
Epilobium billardierianum	0.2	1(1–1)	positive
Geranium retrorsum	0.2	1(1–1)	positive
Haloragis heterophylla	0.2	1(1–1)	positive
Luzula densiflora	0.2	1(1–1)	positive
Oreomyrrhis eriopoda	0.2	1(1–1)	positive
Ranunculus lappaceus	0.2	1(1–1)	positive
Swainsona behriana	0.2	1(1–1)	positive
Vittadinia muelleri	0.2	1(1–1)	positive
Wahlenbergia communis	0.2	1(1–1)	positive

Table 23Ab. Vegetation structure of Map Unit 23A. Frequency is the proportion of samples in which strata were present. Height and cover data are means with standard errors in parentheses (n=5).

Stratum	Frequency	Height (m)	Cover (%)
Tree	0	-	-
Small tree	0	-	-
Shrub	0	-	-
Ground cover	100	0.5(0.1)	81(6)

Table 23Ac. Habitat characteristics of Map Unit 23A. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5° and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		-	-	0
Altitude (m)		982	930–1020	5
Slope (degrees)		3	2–5	5
Terrain class				
North	0			0
Intermediate	20			1
South	20			1
Flat	60			3
Parent material				
Devonian granitoids	40			2
Tertiary Basalt	60			3



Map 23A. Distribution of samples of Monaro Grassland (Map Unit 23A) shown by large black squares. Samples of other map units shown as small grey points.

Plate 23A. Monaro Grassland (Map Unit 23A) remnant dominated by *Poa labillardieri* at Black Lake, west of Cathcart.

Map Unit 23B: Monaro Basalt Grass Woodland

Monaro Basalt Grass Woodland is dominated by *Eucalyptus pauciflora* and *E. viminalis* c. 15 m tall. Scattered shrubs of *Acacia melanoxylon* emerge from a continuous grassy groundcover dominated by *Themeda australis, Poa labillardieri* and *Sorghum leiocladum* and a rich and variable component of forbs including *Acaena nova-zelandiae, Asperula conferta, Chrysocephalum apiculatum* and *Cullen microcephalum*. Monaro Basalt Grass Woodland occurs on relatively well-drained undulating basalt terrain north from Bombala on low-rainfall (generally < 800 mm annual precipitation) parts of the Monaro Tableland. This assemblage is part of a complex of grassy assemblages (Map Units 22–24) on the Monaro Tableland rainshadow area and is distinguished by the rich herbaceous-grassy understorey and relative scarcity of shrubs. With increasing rainfall, it grades into Basalt Wet Herb Forest (Map Unit 16). Nearly 90% of Monaro Basalt Grass Woodland has been cleared for agriculture. The remainder is highly fragmented and occurs mainly on private land where further clearing is the principal

threat, although continuing weed invasion and overgrazing in dry periods are likely to cause a loss of groundcover diversity in stands that escape clearing. Similar vegetation is found elsewhere on the Monaro Tableland, particularly to the north-west around Cooma (Costin 1954). A similar highly depleted assemblage, described as one of two floristic entities within Ecological Vegetation Class 37 (Woodgate et al. 1994), occurs on Honeysuckle Range, west of Bonang in East Gippsland.

Species richness: 17 ± 3 (0.04 ha)
Extant area: 3395 ha
Proportion cleared: 86%
Number of samples: 14

Table 23Ba. Diagnostic plant species of Map Unit 23B.

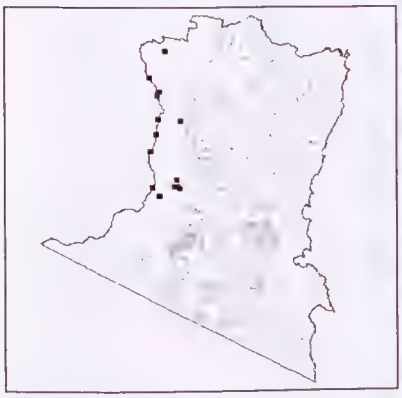
Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Acaena novae-zelandiae	0.5	2(2–2)	0.128	1(1–2)	positive
Asperula conferta	0.786	2(2–3)	0.021	1(1–1)	positive
Bothriochloa macra	0.071	3(3–3)	0	0(0–0)	positive
Chrysocephalum apiculatum	0.357	2(2–3)	0	0(0–0)	positive
Discaria pubescens	0.143	1(1–1)	0	0(0–0)	positive
Eucalyptus pauciflora	0.643	3(2–3)	0.017	1(1–3)	positive
Festuca asperula	0.071	1(1–1)	0	0(0–0)	positive
Leptorhynchos squamatus	0.143	1(1–1)	0	0(0–0)	positive
Poa sieberiana var. *sieberiana*	0.714	3(3–4)	0.064	1(1–2)	positive
Cullen microcephalum	0.5	2(1–2)	0.001	1.5(1–2)	positive
Sorghum leiocladum	0.286	1(1–2)	0	0(0–0)	positive
Austrostipa blackii	0.071	1(1–1)	0	0(0–0)	positive
Themeda australis	0.857	3(2–3)	0.107	2(1–3)	positive
Trachymene humilis	0.071	1(1–1)	0	0(0–0)	positive
Wahlenbergia planiflora subsp. *planiflora*	0.143	1(1–1)	0	0(0–0)	positive
Acacia melanoxylon	0.357	1(1–1)	0.103	1(1–3)	uninformative
Eucalyptus cypellocarpa	0.071	3(3–3)	0.316	3(2–3)	uninformative
Eucalyptus dalrympleana subsp. *dalrympleana*	0.071	3(3–3)	0.018	2.5(1–3)	uninformative
Eucalyptus radiata	0.071	3(3–3)	0.077	3(1–3)	uninformative
Eucalyptus stellulata	0.143	2.5(2–3)	0.001	1(1–1)	uninformative
Eucalyptus viminalis	0.429	3(3–3)	0.054	3(1–3)	uninformative
Lomandra longifolia	0.071	1(1–1)	0.554	2(1–2)	negative
Poa meionectes	0.357	3(3–4)	0.541	2(1–3)	negative
Pteridium esculentum	0	0(2–0)	0.582	2(1–3)	negative

Table 23Bb. Vegetation structure of Map Unit 23B. Frequency is the proportion of samples in which strata were present. Height and cover data are means with standard errors in parentheses (n=5).

Stratum	Frequency (%)	Height (m)	Cover (%)
Tree	100	16.4(3.9)	17(3)
Small tree	0	-(-)	-(-)
Shrub	80	3.6(1.0)	11(6)
Ground cover	100	0.6(0.1)	49(11)

Table 23Bc. Habitat characteristics of Map Unit 23B. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5° and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		762	732–790	14
Altitude (m)		938	823–1070	14
Slope (degrees)		9	3–11	6
Terrain class				
North	0			0
Intermediate	17			1
South	33			2
Flat	50			3
Parent material				
Ordovician high quartz sedimentaries	14			2
Tertiary Alluvium	7			1
Tertiary Basalt	79			11



Map 23B. Distribution of samples of Monaro Basalt Grass Woodland (Map Unit 23B) shown by large black squares. Samples of other map units shown as small grey points.

Plate 23B. Monaro Basalt Grass Woodland (Map Unit 23B) remnant dominated by *Eucalyptus stellulata* and *E. pauciflora* with a grazed grassy understorey comprising *Bothriochloa macra, Poa* spp. and various forbs near Nimmitabel tip.

Map Unit 24: Subalpine Dry Shrub Forest

Subalpine Dry Shrub Forest has a variable tree stratum up to 20 m tall, usually dominated by *Eucalyptus dalrympleana* and *E. radiata,* with *E. pauciflora, E. viminalis* or *E. dives* in varying proportions. Scattered shrubs of *Acacia dealbata* emerge from a stratum of smaller shrubs including *Monotoca scoparia, Bossiaea foliosa, Podolobium procumbens* or *Persoonia chamaepeuce.* The groundcover includes tussocks of *Poa meionectes, P. sieberiana* and *Lomandra longifolia* and scattered forbs such as *Gonocarpus tetragynus.* Subalpine Dry Shrub Forest is a variable unit extending across the Monaro Tableland from the western edge of the escarpment range as a major component of the complex of grassy assemblages (Map Units 22–24) in that rainshadow area. It typically occurs on gentle terrain above 700 m elevation on granitoid substrates or metasediments. Near the escarpment range *E. radiata* is most common and the

assemblage is restricted to frost hollows associated with Subalpine Bogs (Map Unit 59). Further west, the stands are more extensive, *E. pauciflora* becomes more dominant and the graminoid component of the understorey increases. Similar assemblages occur elsewhere on the Monaro Tableland (Costin 1954). In East Gippsland *E. radiata* and *E. dalrympleana* dominate 'better watered lower altitude' stands of Ecological Vegetation Class 36 (Woodgate et al. 1994), although some understorey components may differ. Approximately three-quarters of this extensive unit has been cleared for agriculture and although much of the remainder occurs on private land, there are significant stands in reserves and State Forest on the western edge of the escarpment range. The principal threats include further clearing (on private land), grazing, associated weed invasion and loss of shrub diversity in stands subject to frequent fire regimes.

Species richness: 26 ± 2 (0.04 ha)
Extant area: 26 520 ha
Proportion cleared: 72%
Number of samples: 32

Table 24a. Diagnostic plant species of Map Unit 24.

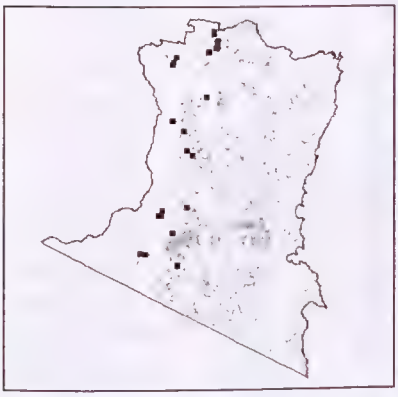
Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Eucalyptus dalrympleana subsp. *dalrympleana*	0.5	3(2–3)	0.012	2(1–3)	positive
Eucalyptus radiata	0.5	3(2–3)	0.071	3(1–3)	positive
Gonocarpus tetragynus	0.6	2(1–2)	0.16	2(1–2)	positive
Monotoca scoparia	0.55	2(2–3)	0.12	2(1–2)	positive
Lomandra longifolia	0.7	2(2–3)	0.547	2(1–2)	frequent
Poa meionectes	0.7	2.5(2–4)	0.537	2(1–3)	frequent
Acacia dealbata	0.35	1(1–2)	0.135	2(1–3)	uninformative
Bossiaea foliosa	0.45	3(2–4)	0.012	1(1–2)	uninformative
Eucalyptus cypellocarpa	0.15	2(1–3)	0.316	3(2–3)	uninformative
Eucalyptus dives	0.35	3(3–3)	0.006	3(1–3)	uninformative
Eucalyptus fastigata	0.05	1(1–1)	0.142	3(3–4)	uninformative
Eucalyptus globoidea	0.05	2(2–2)	0.245	3(1–3)	uninformative
Eucalyptus obliqua	0.05	3(3–3)	0.192	3(2–4)	uninformative
Eucalyptus ovata	0.1	2(2–2)	0.022	3(1–3)	uninformative
Eucalyptus pauciflora	0.45	2(1–3)	0.017	2(1–3)	uninformative
Eucalyptus rubida	0.1	2(1–3)	0.006	1(1–3)	uninformative
Eucalyptus sp. aff. *radiata*	0.05	3(3–3)	0.035	3(2–3)	uninformative
Eucalyptus stellulata	0.05	1(1–1)	0.001	2.5(2–3)	uninformative
Eucalyptus viminalis	0.45	3(3–4)	0.052	3(1–3)	uninformative
Podolobium procumbens	0.3	1.5(1–2)	0.007	2(1–2)	uninformative
Persoonia chamaepeuce	0.3	1(1–2)	0.007	1.5(1–2)	uninformative
Poa sieberiana	0.3	3(3–4)	0.014	1(1–3)	uninformative
Pteridium esculentum	0.25	2(1–2)	0.581	2(1–3)	negative

Table 24b. Vegetation structure of Map Unit 24. Frequency is the proportion of samples in which strata were present. Height and cover data are means with standard errors in parentheses (n=15).

Stratum	Frequency (%)	Height (m)	Cover (%)
Tree	100	18.6(1.3)	29(2)
Small tree	6.7	10.0(-)	10(-)
Shrub	100	1.7(0.2)	28(5)
Ground cover	100	0.3(0.0)	32(7)

Table 24c. Habitat characteristics of Map Unit 24. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5° and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		846	787–917	32
Altitude (m)		924	785–1020	30
Slope (degrees)		8	2–11	30
Terrain class				
North	7			2
Intermediate	30			9
South	17			5
Flat	47			14
Parent material				
Devonian granitoids	53			17
Devonian high quartz sedimentaries	6			2
Low quartz sedimentaries	13			4
Ordovician high quartz sedimentaries	22			7
Tertiary Basalt	6			2



Map 24. Distribution of samples of Subalpine Dry Shrub Forest (Map Unit 24) shown by large black squares. Samples of other map units shown as small grey points.

Plate 24. Subalpine Dry Shrub Forest (Map Unit 24) dominated by *Eucalyptus pauciflora, E. dalrympleana* and *E. radiata* with *Gahnia subaequiglumis* and *Bossiaea foliosa* adjacent to Nunnock Swamp, Tantawangalo section, South East Forests National Park.

Map Unit 25: Sandstone Dry Shrub Forest

Sandstone Dry Shrub Forest is c. 20 m tall and dominated by *Eucalyptus obliqua* and *E.* sp. aff. *radiata* (a variant with broader, more glaucous juvenile leaves than the type form), often with *E. sieberi*. A prominent sclerophyllous shrub stratum includes *Acacia mucronata, Epacris impressa, Platysace lanceolata, Lomatia ilicifolia* and *Oxylobium arborescens* or *Persoonia chamaepeuce*. The relatively dense groundcover is dominated by bracken, *Pteridium esculentum* and wiregrass, *Tetrarrhena juncea*, with other grasses and graminoids, notably *Lomandra longifolia* and *Poa meionectes*, and herbs including *Amperea xiphoclada, Dianella tasmanica, Viola hederacea* and *Gonocarpus teucrioides*. Sandstone Dry Shrub Forest is restricted to elevated ridges on the Genoa sandstone and nearby sites on quartz-rich granitoid substrates and metasediments, usually

above 700 m elevation. Although about one-quarter of its distribution has been cleared for pine plantations, the principal occurrences on Nungatta Mountain and Mt Tennyson are represented within conservation reserves. Future clearing is therefore unlikely to pose a significant threat. Frequent fire regimes that reduce diversity by interrupting life-cycle processes of woody species are likely to be the main threat to this assemblage. The high densities of *P. esculentum, T. juncea* and *A. mucronata* may reflect the passage of a high intensity fire that burnt almost the entire range of Sandstone Dry Shrub Forest in 1983. Intervals between planned and unplanned fires need to be long enough to allow replenishment of seed banks and restoration of habitat structure if losses of diversity are to be avoided. Although no similar assemblage has been described in East Gippsland (Forbes et al. 1982), one may occur within the Shrubby Dry Forest complex (Ecological Vegetation Class 21, Woodgate et al. 1994) on nearby elevated sandstone areas such as Mt Coopracambra.

Species richness: 22 ± 1 (0.04 ha)

Extant area: 821 ha

Proportion cleared: 28%

Number of samples: 10

Table 25a. Diagnostic plant species of Map Unit 25.

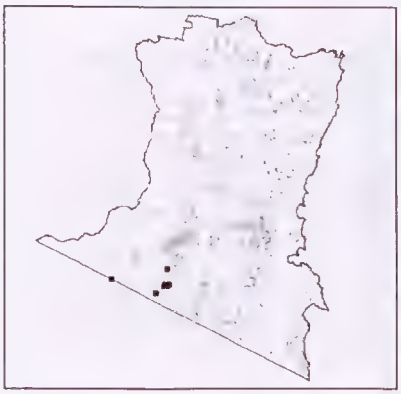
Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Acacia mucronata	0.8	4(2–4)	0.049	1(1–3)	positive
Amperea xiphoclada	0.6	2(1–2)	0.057	1(1–2)	positive
Dianella tasmanica	0.5	2(2–3)	0.233	1(1–2)	positive
Epacris impressa	0.9	3(2–3)	0.192	2(1–2)	positive
Eucalyptus obliqua	0.7	3(1–3)	0.186	3(2–4)	positive
Eucalyptus sp. aff. *radiata*	0.5	3(2–3)	0.032	3(2–3)	positive
Platysace lanceolata	0.9	2(2–3)	0.247	2(1–2)	positive
Tetrarrhena juncea	0.5	2(2–3)	0.18	2(1–3)	positive
Viola hederacea subsp. *hederacea*	0.5	2(1–2)	0.437	2(1–2)	positive
Lomandra longifolia	1	3(3–4)	0.546	2(1–2)	frequent
Poa meionectes	0.7	2(1–4)	0.538	2(1–3)	frequent
Pteridium esculentum	0.8	2.5(2–4)	0.575	2(1–3)	frequent
Gonocarpus teucrioides	0.6	1.5(1–2)	0.314	2(1–2)	frequent
Lomatia ilicifolia	0.8	1(1–1)	0.127	1(1–2)	frequent
Oxylobium arborescens	0.6	1.5(1–3)	0.014	2(1–3)	frequent
Eucalyptus angophoroides	0.1	3(3–3)	0.044	2(1–3)	uninformative
Eucalyptus consideniana	0.1	4(4–4)	0.021	2(1–3)	uninformative
Eucalyptus cypellocarpa	0.2	3(3–3)	0.315	3(2–3)	uninformative
Eucalyptus elata	0.1	3(3–3)	0.113	3(2–3)	uninformative
Eucalyptus globoidea	0.1	2(2–2)	0.244	3(1–3)	uninformative
Eucalyptus mackintii	0.1	4(4–4)	0.003	3(3–4)	uninformative
Eucalyptus radiata	0.2	2(2–2)	0.076	3(1–3)	uninformative
Eucalyptus sieberi	0.4	3(2–4)	0.282	3(2–4)	uninformative

Table 25b. Vegetation structure of Map Unit 25. Frequency is the proportion of samples in which strata were present. Height and cover data are means with standard errors in parentheses (n=10).

Stratum	Frequency (%)	Height (m)	Cover (%)
Tree	100	21.4(2.1)	30(4)
Small tree	0	-(-)	-(-)
Shrub	100	1.6(0.2)	38(6)
Ground cover	100	0.5(0.1)	44(6)

Table 25c. Habitat characteristics of Map Unit 25. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5° and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°). Note extreme values for one sample have been ommitted from the annual rain (955 mm) and altitude (380 m) summary statistics.

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		1200	1193–1230	9
Altitude (m)		850	830–980	9
Slope (degrees)		6	2–7	10
Terrain class				
North	10			1
Intermediate	40			4
South	0			0
Flat	50			5
Parent material				
Devonian granitoids	10			1
Devonian high quartz sedimentaries	80			8
Ordovician high quartz sedimentaries	10			1



Map 25. Distribution of samples of Sandstone Dry Shrub Forest (Map Unit 25) shown by large black squares. Samples of other map units shown as small grey points.

Plate 25. Sandstone Dry Shrub Forest (Map Unit 25) dominated by *Eucalyptus obliqua, E. sieberi* and *E.* sp. aff. *radiata* with *Acacia mucronata, Ozothamnus cuneifolius* and *Persoonia brevifolia* on Nungatta Plateau, Genoa section, South East Forests National Park.

Map Unit 26: Tableland Dry Shrub Forest

Tableland Dry Shrub Forest is dominated by *Eucalyptus globoidea, E. radiata* and *E. cypellocarpa* up to 30 m tall. An open sclerophyllous shrub stratum is dominated by Epacridaceae: *Epacris impressa; Leucopogon lanceolatus;* and *Monotoca scoparia,* with *Hibbertia obtusifolia.* The groundcover is relatively sparse and includes grasses and graminoids *Dichelachne rara, Lomandra longifolia, Microlaena stipoides* and *Poa meionectes,* herbs *Gonocarpus tetragynus, Viola hederacea* and *Dianella caerulea* and bracken, *Pteridium esculentum.* Tableland Dry Shrub Forest occurs on ridges and dry slopes on metasediments and granitoid substrates at 300–850 m elevation in the south-western part of the study area. Forbes et al. (1982) described a similar assemblage (Community 9.3) scattered through the foothills of East Gippsland, but this differs in some

compositional aspects (e.g. low frequency of *E. radiata*). About two-fifths of Tableland Dry Shrub Forest has been cleared, mainly for pine plantation and about two-thirds of the remainder occurs on State Forest and private land available for logging. Although a further 3200 ha of this vegetation is potentially threatened by further clearing, the principal threat to stands outside reserves is frequent disturbance regimes that include logging and fire in combination. These regimes reduce diversity by interrupting life-cycle processes of woody species (Keith 1996). Logging followed by regeneration burns and thinning may change the relative abundance of eucalypt species, particularly *E. sieberi* (Bridges 1983). Intervals between planned and unplanned disturbances need to be long enough to allow replenishment of seed banks and restoration of habitat structure if losses of diversity are to be avoided.

Species richness: 32± 2 (0.04 ha)
Extant area: 16 080 ha
Proportion cleared: 43%
Number of samples: 34

Table 26a. Diagnostic plant species of Map Unit 26.

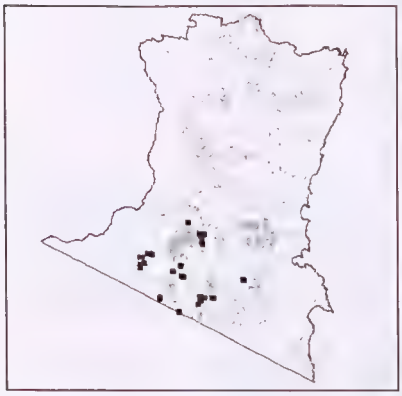
Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Dichelachne rara	0.5	2(1–2)	0.162	1(1–2)	positive
Epacris impressa	0.853	2(1–2)	0.181	2(1–2)	positive
Eucalyptus cypellocarpa	0.5	3(2–3)	0.31	3(2–3)	positive
Eucalyptus globoidea	0.677	3(2–3)	0.232	3(1–3)	positive
Eucalyptus radiata	0.588	3(2–3)	0.065	3(1–3)	positive
Gonocarpus tetragynus	0.5	2(1–2)	0.158	2(1–2)	positive
Helichrysum rutidolepis	0.029	2(2–2)	0	0(0–0)	positive
Leucopogon lanceolatus var. *lanceolatus*	0.824	2(1–2)	0.396	1(1–2)	positive
Microtis parviflora	0.029	1(1–1)	0	0(0–0)	positive
Viola hederacea subsp. *hederacea*	0.588	2(1–2)	0.434	2(1–2)	positive
Lomandra longifolia	1	2(2–2)	0.538	2(1–2)	frequent
Poa meionectes	0.971	2(2–3)	0.529	2(1–3)	frequent
Pteridium esculentum	0.677	2(2–3)	0.574	2(1–3)	frequent
Dianella caerulea	0.882	1(1–2)	0.264	1(1–2)	frequent
Hibbertia obtusifolia	0.677	1(1–2)	0.073	1(1–2)	frequent
Microlaena stipoides var. *stipoides*	0.647	1(1–2)	0.347	2(1–2)	frequent
Monotoca scoparia	0.618	1(1–2)	0.114	2(1–2)	frequent
Eucalyptus angophoroides	0.265	3(2–4)	0.039	2(1–3)	uninformative
Eucalyptus croajingolensis	0.059	3(3–3)	0.001	2(2–2)	uninformative
Eucalyptus dalrympleana subsp. *dalrympleana*	0.177	2.5(1–3)	0.015	3(1–3)	uninformative
Eucalyptus dives	0.029	3(3–3)	0.01	3(2–3)	uninformative
Eucalyptus elata	0.029	1(1–1)	0.115	3(2–3)	uninformative
Eucalyptus mackintii	0.029	3(3–3)	0.003	3(3–4)	uninformative
Eucalyptus muelleriana	0.029	3(3–3)	0.145	3(2–4)	uninformative
Eucalyptus obliqua	0.265	3(2–3)	0.188	3(2–4)	uninformative
Eucalyptus ovata	0.059	1(1–1)	0.022	3(1–3)	uninformative
Eucalyptus polyanthemos subsp. *vestita*	0.029	1(1–1)	0.014	2(2–3)	uninformative
Eucalyptus sieberi	0.235	3(2–3)	0.284	3(2–4)	uninformative
Eucalyptus sp. aff. *radiata*	0.088	4(3–4)	0.034	3(2–3)	uninformative
Eucalyptus viminalis	0.206	1(1–3)	0.054	3(1–3)	uninformative

Table 26b. Vegetation structure of Map Unit 26. Frequency is the proportion of samples in which strata were present. Height and cover data are means with standard errors in parentheses (n=29).

Stratum	Frequency (%)	Height (m)	Cover (%)
Tree	100	28.6(1.0)	29(2)
Small tree	37.9	8.0(0.9)	18(3)
Shrub	100	2.1(0.2)	27(4)
Ground cover	100	0.5(0.0)	18(2)

Table 26c. Habitat characteristics of Map Unit 26. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5°and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		972	944–1002	34
Altitude (m)		549	383–714	34
Slope (degrees)		8	3–10	34
Terrain class				
North	21			7
Intermediate	29			10
South	18			6
Flat	32			11
Parent material				
Devonian granitoids	74			25
Devonian high quartz sedimentaries	9			3
Ordovician high quartz sedimentaries	18			6



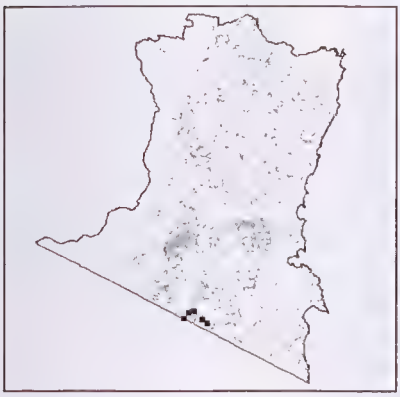
Map 26. Distribution of samples of Tableland Dry Shrub Forest (Map Unit 26) shown by large black squares. Samples of other map units shown as small grey points.

Plate 26. Nalbaugh Dry Grass Forest (Map Unit 26) dominated by *Eucalyptus viminalis* and *E. angophoroides* with *Acacia dealbata, Poa meionectes, Lomandra longifolia* and *Gahnia sieberiana* near Walla Walla Creek, Waalimma section of South East Forests National Park.

Map Unit 27: Waalimma Dry Grass Forest

Waalimma Dry Grass Forest has a variable tree stratum dominated by *Eucalyptus angophoroides, E. globoidea, E. sieberi, E. tricarpa* and *E. polyanthemos* in various combinations. Trees are up to 25 m tall. A sclerophyllous shrub stratum includes *Acacia mucronata, Epacris impressa* and *Pultenaea scabra,* while the rich and distinctive grassy

understorey is dominated by *Themeda australis* and graminoids, *Gahnia radula, Lomandra multiflora* and *Lepidosperma laterale,* with small shrubs, *Astroloma humifusum, Lissanthe strigosa* and *Hibbertia obtusifolia,* and herbs *Gonocarpus tetragynus, Helichrysum scorpioides, Bossiaea prostrata, Hypericum gramineum, Viola hederacea* and *Dianella* spp. and the twiner, *Billardiera scandens.* Waalimma Dry Grass Forest occurs on broad ridges and upper slopes on metasediments and granitoid substrates at 350–500 m elevation. It has a highly restricted distribution around Mt Waalimma close to the Victorian border, primarily on State Forest. Forbes et al. (1982) recorded a similar assemblage on adjacent sites across the Victorian border (Box-Ironbark Woodland, Community 10.1). However, these stands appear to differ substantially in composition and habitat from other stands attributed to Box-Ironbark elsewhere in the foothills of East Gippsland. Foothill Box-Ironbark Forest (Ecological Vegetation Class 24) described by Woodgate et al. (1994) shares two tree species (*E. polyanthemos* and *E. tricarpa*) with Waalimma Dry Grass Forest, but has a structurally different shrubby understorey (cf. grassy) with none of the major species in common. The Victorian assemblage occurs in two highly restricted stands (c. 600 ha) on limestone and metasediments (Woodgate et al. 1994). It therefore seems unlikely that Waalimma Dry Grass Forest occurs in Victoria beyond areas adjacent to the border. The principal threat facing Waalimma Dry Grass Forest is high frequency disturbance regimes associated with timber production. The largest area of this vegetation includes tree stands of post-1952 fire regrowth which are scheduled for intensive silvicultural management for thinnings and sawlog production in the first decades of the twenty-first century. Frequent disturbance regimes including logging, thinning and burning may reduce diversity by interrupting life-cycle processes of woody species (Keith 1996). Logging followed by regeneration burns and thinning may change the relative abundance of eucalypt species, particularly *E. sieberi* (Bridges 1983). Intervals between planned and unplanned disturbances need to be long enough to allow replenishment of seed banks and restoration of habitat structure if losses of diversity from this distinctive, species-rich assemblage are to be avoided.



Map 27. Distribution of samples of Waalimma Dry Grass Forest (Map Unit 27) shown by large black squares. Samples of other map units shown as small grey points.

Plate 27. Waalimma Dry Grass Forest (Map Unit 27) dominated by *Eucalyptus tricarpa, E. angophoroides* and *E. globoidea* with *Acacia mucronata, A. stricta, Lissanthe strigosa, Gahnia radula* and *Echinopogon ovatus* on the northern toeslope of Mt Waalimma, Waalimma section, South East Forest National Park.

Species richness: 38 ± 2 (0.04 ha)
Extant area: 1324 ha
Proportion cleared: 0%
Number of samples: 5

Table 27a. Diagnostic plant species of Map Unit 27.

Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Acacia mucronata	0.6	3(1–3)	0.052	1(1–3)	positive
Astroloma humifusum	1	2(1–4)	0.05	1(1–2)	positive
Epacris impressa	0.6	3(3–3)	0.195	2(1–2)	positive
Eucalyptus angophoroides	0.8	2.5(1–3)	0.042	2(1–3)	positive
Eucalyptus globoidea	0.8	2(2–3)	0.241	3(1–3)	positive
Eucalyptus sieberi	0.6	2(1–3)	0.282	3(2–4)	positive
Eucalyptus tricarpa	0.6	3(3–4)	0.02	2(1–3)	positive
Gahnia radula	1	3(3–4)	0.088	2(1–3)	positive
Gonocarpus tetragynus	0.6	2(2–2)	0.164	2(1–2)	positive
Helichrysum scorpioides	0.8	2(1–2)	0.13	1(1–2)	positive
Lepidosperma laterale	1	2(1–2)	0.342	1(1–2)	positive
Lissanthe strigosa	1	2(1–3)	0.009	1(1–3)	positive
Lomandra filiformis subsp. *flavior*	0.6	2(1–3)	0.017	1(1–2)	positive
Pultenaea scabra var. *scabra*	0.6	2(1–3)	0.005	2(1–3)	positive
Themeda australis	1	2(1–3)	0.111	2(1–3)	positive
Billardiera scandens	0.8	1.5(1–2)	0.327	1(1–1)	frequent
Bossiaea prostrata	0.8	1.5(1–2)	0.027	1(1–1)	frequent
Burchardia umbellata	0.6	1(1–1)	0.019	1(1–2)	frequent
Deyeuxia quadriseta	0.6	1(1–1)	0.041	1(1–1)	frequent
Dianella caerulea	0.8	1.5(1–2)	0.277	1(1–2)	frequent
Dianella revoluta var. *revoluta*	0.6	1(1–2)	0.08	1(1–1)	frequent
Dichelachne micrantha	0.6	1(1–2)	0.084	1(1–2)	frequent
Dichelachne rara	0.6	1(1–2)	0.168	1(1–2)	frequent
Eucalyptus polyanthemos subsp. *vestita*	0.6	1(1–3)	0.011	2.5(2–3)	frequent
Hibbertia empetrifolia	0.6	1(1–2)	0.063	1(1–2)	frequent
Hypericum gramineum	0.8	1(1–2)	0.24	1(1–2)	frequent
Lomandra multiflora	1	1(1–2)	0.249	1(1–2)	frequent
Eucalyptus agglomerata	0.4	2(1–3)	0.108	3(2–3)	uninformative
Eucalyptus bosistoana	0.2	4(4–4)	0.052	2(1–3)	uninformative
Lomandra longifolia	0.4	2(1–3)	0.549	2(1–2)	negative
Poa meionectes	0.4	3.5(3–4)	0.539	2(1–3)	negative
Pteridium esculentum	0.2	1(1–1)	0.578	2(1–3)	negative

Table 27b. Vegetation structure of Map Unit 27. Frequency is the proportion of samples in which strata were present. Height and cover data are means with standard errors in parentheses (n=5).

Stratum	Frequency (%)	Height (m)	Cover (%)
Tree	100	22.6(2.2)	25(3)
Small tree	20	12.0(-)	20(-)
Shrub	100	1.6(0.2)	29(7)
Ground cover	100	0.5(0.0)	58(6)

Table 27c. Habitat characteristics of Map Unit 27. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5° and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		1036	1018–1040	5
Altitude (m)		405	370–405	5
Slope (degrees)		8	6–9	5
Terrain class				
North	20			1
Intermediate	40			2
South	40			2
Flat	0			0
Parent material				
Devonian granitoids	60			3
Ordovician high quartz sedimentaries	40			2

Map Unit 28: Wog Wog Dry Grass Forest

Wog Wog Dry Grass Forest is dominated by *Eucalyptus agglomerata,* and *E. maidenii,* occasionally with *E. angophoroides* up to 30 m tall. A sparse cover of sclerophyllous shrubs includes *Leucopogon lanceolatus, Hibbertia obtusifolia* and *Senecio linearifolius.* The species-rich, semi-continuous groundcover is dominated by grasses and graminoids *Poa meionectes, Agrostis avenacea* and *Notodanthonia pilosa,* with a rich array of herbs including *Ajuga australis, Geranium potentilloides, Poranthera microphylla, Viola hederacea, Acaena nova-zelandiae, Desmodium varians, Gonocarpus teucrioides, Hydrocotyle acutiloba, Hypericum gramineum, Oxalis perennans, Plantago debilis* and *Wahlenbergia* spp. The groundcover also includes prostrate shrubs of *Astroloma humifusum* and twining plants of *Glycine clandestina.* Wog Wog Dry Grass Forest is restricted to gentle lower slopes on granitoid substrates at 400–500 m elevation in the Wog Wog Creek area. No similar assemblages have been described outside the Eden region (Austin 1978, Woodgate et al. 1994). About one third of Wog Wog Dry Grass Forest has been cleared for agriculture and is now under pine plantation. Most of the remainder is in a national park, where fire regimes and feral pigs are the main management concerns. Diggings of feral pigs, which have been present in appreciable numbers in this area, potentially threaten the groundcover with loss of diversity and weed invasion.

Species richness: 34 ± 2 (0.1 ha)

Extant area: 922 ha

Proportion cleared: 29%

Number of samples: 10

Table 28a. Diagnostic plant species of Map Unit 28.

Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Ajuga australis	0.5	2(2–2)	0.04	1(1–1)	positive
Eucalyptus agglomerata	0.9	3(3–4)	0.103	3(2–3)	positive
Eucalyptus maidenii	0.9	3(2–3)	0.057	3(3–3)	positive
Geranium potentilloides	0.6	2(1–2)	0.213	1(1–2)	positive
Leptospermum parvifolium	0.2	3(2–4)	0	0(0–0)	positive

Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Poranthera microphylla	0.9	2(1–2)	0.219	1(1–1)	positive
Viola hederacea subsp. *hederacea*	0.7	2(1–2)	0.436	2(1–2)	positive
Poa meionectes	1	5(4–6)	0.536	2(1–3)	frequent
Acaena novae-zelandiae	0.7	1(1–1)	0.128	1(1–2)	frequent
Agrostis avenacea	0.7	1(1–2)	0.023	1(1–1)	frequent
Astroloma humifusum	0.8	1(1–2)	0.048	1(1–2)	frequent
Notodanthonia pilosa var. *pilosa*	0.8	1(1–2)	0.06	1(1–1)	frequent
Desmodium varians	0.7	1(1–1)	0.247	1(1–2)	frequent
Glycine clandestina	0.7	1(1–2)	0.325	1(1–2)	frequent
Gonocarpus teucrioides	0.8	1(1–2)	0.313	2(1–2)	frequent
Hibbertia obtusifolia	0.6	1(1–2)	0.083	1(1–2)	frequent
Hydrocotyle acutiloba	0.9	1(1–2)	0.192	1(1–2)	frequent
Hypericum gramineum	0.8	1(1–2)	0.238	1(1–2)	frequent
Lagenifera stipitata	0.8	1.5(1–2)	0.321	1(1–2)	frequent
Leucopogon lanceolatus var. *lanceolatus*	1	1.5(1–2)	0.402	1(1–2)	frequent
Lomandra multiflora	0.6	1(1–2)	0.249	1(1–2)	frequent
Oxalis perennans	0.7	1(1–2)	0.219	1(1–1)	frequent
Plantago debilis	0.7	1(1–2)	0.109	1(1–1)	frequent
Senecio linearifolius	0.9	1(1–2)	0.235	1(1–2)	frequent
Senecio sp. E	0.6	1(1–2)	0.19	1(1–2)	frequent
Wahlenbergia gracilis	0.6	1(1–1)	0.135	1(1–1)	frequent
Wahlenbergia stricta subsp. *stricta*	0.7	1(1–2)	0.069	1(1–1)	frequent
Eucalyptus angophoroides	0.4	1(1–3)	0.042	2(1–3)	uninformative
Eucalyptus dalrympleana subsp. *dalrympleana*	0.1	1(1–1)	0.018	3(1–3)	uninformative
Eucalyptus elata	0.1	2(2–2)	0.113	3(2–3)	uninformative
Eucalyptus globoidea	0.1	4(4–4)	0.244	3(1–3)	uninformative
Eucalyptus muelleriana	0.1	1(1–1)	0.142	3(2–4)	uninformative
Eucalyptus sieberi	0.1	2(2–2)	0.284	3(2–4)	uninformative
Lomandra longifolia	0.4	2.5(1–3)	0.55	2(1–2)	negative
Pteridium esculentum	0.4	2(1–2)	0.578	2(1–3)	negative

Map 28. Distribution of samples of Wog Wog Dry Grass Forest (Map Unit 28) shown by large black squares. Samples of other map units shown as small grey points.

Plate 28. Wog Wog Dry Grass Forest (Map Unit 24) dominated by *Eucalyptus maidenii* and *E. agglomerata* with *Leucopogon lanceolatus*, *Poa meionectes* and *Pteridium esculentum* on Conga Road near Wog Wog River, Coolangubra section, South East Forests National Park.

Table 28b. Vegetation structure of Map Unit 28. Frequency is the proportion of samples in which strata were present. Height and cover data are means with standard errors in parentheses (n=10).

Stratum	Frequency (%)	Height (m)	Cover (%)
Tree	100	28.5(1.1)	34(3)
Small tree	30	6.3(0.9)	11(5)
Shrub	100	2.5(0.4)	14(5)
Ground cover	100	0.4(0.1)	69(8)

Table 28c. Habitat characteristics of Map Unit 28. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5° and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		920	916–927	10
Altitude (m)		467	453–480	10
Slope (degrees)		9	8–10	10
Terrain class				
North	10			1
Intermediate	50			5
South	30			3
Flat	10			1
Parent material				
Devonian granitoids	100			10

Map Unit 29: Nalbaugh Dry Grass Forest

Nalbaugh Dry Grass Forest is dominated by *Eucalyptus globoidea* and *E. cypellocarpa* over 25 m tall, occasionally with *E.* sp. aff. *radiata, E. ovata* or *E. sieberi.* An open shrub stratum is dominated by *Cassinia aculeata* with *Epacris impressa* and *Leucopogon lanceolatus.* The groundcover has a moderate density and comprises grasses and graminoids *Lomandra longifolia, Poa meionectes, Microlaena stipoides* and *Luzula flaccida,* and with a diverse compliment of forbs including *Gonocarpus tetragynus, Viola hederacea, Geranium potentilloides, Helichrysum scorpioides, Hydrocotyle acutiloba, Lagenifera stipitata, Poranthera microphylla* and *Senecio* sp. E. Nalbaugh Dry Grass Forest occurs on lower granitoid slopes at 500–850 m elevation on the southern part of the escarpment range. It differs from Tableland Dry Shrub Forest (Map Unit 26) in its subdominant tree species and the greater diversity of forbs in its more developed groundcover. Its composition does not readily match any of the assemblages described in adjacent regions (Austin 1978, Forbes et al. 1982), however, there may be restricted occurrences within the Grassy Dry Forest complex in East Gippsland (Woodgate et al. 1994). One-quarter of Nalbaugh Dry Grass Forest has been cleared and three-fifths of the remainder occurs on State Forest and private land available for logging. The principal threat to stands outside reserves is frequent disturbance regimes that include logging and fire in combination, although the impact of these regimes is likely to be less severe than in assemblages with more diverse woody components. Logging followed by regeneration burns and thinning may change the relative abundance of eucalypt species, particularly *E. sieberi* (Bridges 1983). Intervals between planned and unplanned disturbances need to be long enough to allow replenishment of seed banks and restoration of habitat structure if losses of diversity are to be avoided.

Species richness: 39 ± 3 (0.1 ha)
Extant area: 1937 ha
Proportion cleared: 25%
Number of samples: 17

Table 29a. Diagnostic plant species of Map Unit 29.

Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Cassinia aculeata	0.824	2.5(1–3)	0.155	1(1–2)	positive
Dillwynia retorta	0.059	3(3–3)	0	0(0–0)	positive
Drosera glanduligera	0.059	1(1–1)	0	0(0–0)	positive
Eucalyptus cypellocarpa	0.824	3(2–4)	0.308	3(2–3)	positive
Eucalyptus globoidea	0.941	4(3–4)	0.234	3(1–3)	positive
Gonocarpus tetragynus	0.529	2(2–3)	0.162	2(1–2)	positive
Viola hederacea subsp. *hederacea*	0.765	2(1–2)	0.434	2(1–2)	positive
Lomandra longifolia	0.941	2(2–3)	0.544	2(1–2)	frequent
Poa meionectes	0.882	3(2–4)	0.535	2(1–3)	frequent
Epacris impressa	0.765	1(1–2)	0.19	2(1–2)	frequent
Geranium potentilloides	0.647	1(1–1)	0.211	1(1–2)	frequent
Helichrysum scorpioides	0.647	1(1–2)	0.126	1(1–2)	frequent
Hydrocotyle acutiloba	0.765	1(1–2)	0.19	1(1–2)	frequent
Lagenifera stipitata	0.941	1(1–2)	0.317	1(1–2)	frequent
Leucopogon lanceolatus var. *lanceolatus*	0.882	1(1–2)	0.4	1(1–2)	frequent
Luzula flaccida	0.882	1(1–1)	0.092	1(1–1)	frequent
Microlaena stipoides var. *stipoides*	0.706	1(1–2)	0.35	2(1–2)	frequent
Poranthera microphylla	0.824	1(1–2)	0.217	1(1–1)	frequent
Senecio sp. E	0.706	1(1–1)	0.187	1(1–2)	frequent
Eucalyptus maidenii	0.059	1(1–1)	0.063	3(2–3)	uninformative
Eucalyptus obliqua	0.059	1(1–1)	0.191	3(2–4)	uninformative
Eucalyptus ovata	0.294	1(1–4)	0.02	3(2–3)	uninformative
Eucalyptus radiata	0.059	3(3–3)	0.077	3(1–3)	uninformative
Eucalyptus sieberi	0.235	1(1–3)	0.283	3(2–4)	uninformative
Eucalyptus sp. aff. *radiata*	0.471	3(2–3)	0.03	3(2–3)	uninformative
Eucalyptus viminalis	0.177	3(1–4)	0.056	3(1–3)	uninformative
Pteridium esculentum	0.471	2(1–3)	0.578	2(1–3)	negative

Table 29b. Vegetation structure of Map Unit 29. Frequency is the proportion of samples in which strata were present. Height and cover data are means with standard errors in parentheses (n=8).

Stratum	Frequency (%)	Height (m)	Cover (%)
Tree	100	27.1(1.5)	44(3)
Small tree	12.5	8.0(-)	20(-)
Shrub	100	3.1(0.3)	33(7)
Ground cover	100	0.4(0.1)	47(7)

Table 29c. Habitat characteristics of Map Unit 29. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5°and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		969	957–987	17
Altitude (m)		606	560–650	17
Slope (degrees)		9	4–12	17
Terrain class				
North	6			1
Intermediate	41			7
South	24			4
Flat	29			5
Parent material				
Devonian granitoids	100			17

Map 29. Distribution of samples of Nalbaugh Dry Grass Forest (Map Unit 29) shown by large black squares. Samples of other map units shown as small grey points.

Plate 29. Nalbaugh Dry Grass Forest (Map Unit 29) dominated by *Eucalyptus radiata, E. viminalis* and *E. globoidea* with *Kunzea ericoides* and *Poa meionectes* on the summit of Big Jack Mountain, Coolangubra section of South East Forests National Park.

Map Unit 30: Wallagaraugh Dry Grass Forest

Wallagaraugh Dry Grass Forest has a variable tree stratum exceeding 25 m in height, usually with *Eucalyptus cypellocarpa* and *E. globoidea,* or occasionally with *E. radiata, E. viminalis* or *E. angophoroides.* An open shrub stratum is dominated by *Acacia mearnsii* and *Exocarpos strictus,* with the former species sometimes attaining the size of small trees. The species-rich groundcover has a moderate density and comprises grasses and graminoids *Poa meionectes, Microlaena stipoides* and *Lomandra longifolia* and forbs *Dichondra repens, Viola hederacea, Hypericum gramineum, Lagenifera stipitata* and *Senecio* sp. E, twiners of *Glycine clandestina* and bracken, *Pteridium esculentum.* Wallagaraugh Dry Grass Forest is restricted to relatively small stands on lower slopes, usually on granitoid substrates at 100–500 m elevation in the southern hinterland. It generally occurs at lower elevation, extending into damper habitats than Tableland Dry Shrub Forest (Map Unit 26) and Nalbaugh Dry Grass Forest (Map Unit 29), and has a more

variable composition of trees and less sclerophyllous compliment of shrub species than these other assemblages. In broad open valleys Wallagaraugh Dry Grass Forest may grade into Swamp Forest (Map Unit 59) which occupies the most low-lying waterlogged sites in the catchment. Its composition does not readily match any of the assemblages described in adjacent regions (Austin 1978, Forbes et al. 1982), however, there may be restricted occurrences within the Grassy Dry Forest complex in the foothills of East Gippsland (Woodgate et al. 1994). Almost half of Wallagaraugh Dry Grass Forest has been cleared, mainly for pine plantation and three-fifths of the remainder occurs on State Forest and private land available for logging. Stands on private land are potentially threatened by further clearing. Frequent disturbance regimes that include logging (outside reserves) and fire in combination may reduce diversity by interrupting life-cycle processes of woody species and increase rates of sedimentation. Feral pigs also pose a threat to soils and the diverse ground flora through their diggings.

Species richness: 42 ± 2 (0.04 ha)

Extant area: 914 ha

Proportion cleared: 45%

Number of samples: 17

Table 30a. Diagnostic plant species of Map Unit 30.

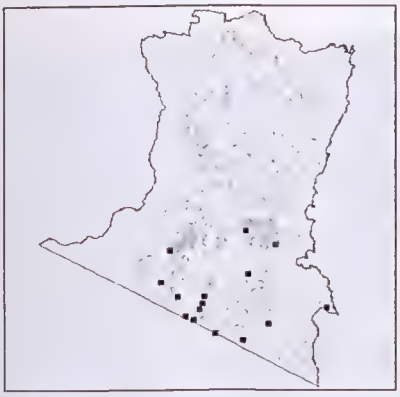
Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Acacia mearnsii	0.588	2.5(1–4)	0.158	2(1–3)	positive
Bracteantha viscosa	0.059	2(2–2)	0	0(0–0)	positive
Dichondra repens	0.647	2(1–2)	0.28	2(1–2)	positive
Eucalyptus cypellocarpa	0.647	3(2–3)	0.31	3(2–3)	positive
Eucalyptus globoidea	0.529	2(1–3)	0.239	3(1–3)	positive
Microlaena stipoides var. *stipoides*	0.765	2(1–2)	0.349	2(1–2)	positive
Pultenaea polifolia	0.059	1(1–1)	0	0(0–0)	positive
Thelymitra cyanea	0.059	1(1–1)	0	0(0–0)	positive
Viola hederacea subsp. *hederacea*	0.882	2(1–2)	0.432	2(1–2)	positive
Lomandra longifolia	0.765	2(1–5)	0.546	2(1–2)	frequent
Poa meionectes	0.882	2(1–2)	0.535	2(1–3)	frequent
Pteridium esculentum	0.706	2(1–3)	0.575	2(1–3)	frequent
Exocarpos strictus	0.647	1(1–2)	0.165	1(1–2)	frequent
Glycine clandestina	0.765	1(1–2)	0.322	1(1–2)	frequent
Hypericum gramineum	0.765	1(1–2)	0.236	1(1–2)	frequent
Lagenifera stipitata	0.824	1(1–1)	0.318	1(1–2)	frequent
Senecio sp. E	0.647	1(1–2)	0.188	1(1–2)	frequent
Angophora floribunda	0.059	1(1–1)	0.096	2(1–3)	uninformative
Eucalyptus agglomerata	0.059	1(1–1)	0.109	3(2–3)	uninformative
Eucalyptus angophoroides	0.235	2(1–3)	0.042	2(1–3)	uninformative
Eucalyptus bosistoana	0.118	3(2–4)	0.052	2(1–3)	uninformative
Eucalyptus elata	0.177	4(3–4)	0.112	3(2–3)	uninformative
Eucalyptus longifolia	0.059	4(4–4)	0.03	3(2–3)	uninformative
Eucalyptus muelleriana	0.177	3(1–3)	0.142	3(2–4)	uninformative
Eucalyptus obliqua	0.118	2(1–3)	0.19	3(2–4)	uninformative
Eucalyptus ovata	0.177	3(3–4)	0.021	2(1–3)	uninformative
Eucalyptus radiata	0.353	1(1–2)	0.074	3(1–3)	uninformative
Eucalyptus sieberi	0.059	3(3–3)	0.285	3(2–4)	uninformative
Eucalyptus viminalis	0.294	3(1–3)	0.054	3(1–3)	uninformative

Table 30b. Vegetation structure of Map Unit 30. Frequency is the proportion of samples in which strata were present. Height and cover data are means with standard errors in parentheses (n=11).

Stratum	Frequency (%)	Height (m)	Cover (%)
Tree	100	26.0(3.2)	25(3)
Small tree	54.5	10.8(1.0)	24(7)
Shrub	90.9	2.5(0.4)	28(5)
Ground cover	100	0.4(0.1)	46(7)

Table 30c. Habitat characteristics of Map Unit 30. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5° and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		949	930–982	17
Altitude (m)		313	230–380	17
Slope (degrees)		8	2–11	17
Terrain class				
North	18			3
Intermediate	18			3
South	18			3
Flat	47			8
Parent material				
Devonian granitoids	65			11
Low quartz sedimentaries	12			2
Ordovician high quartz sedimentaries	18			3
Tertiary Alluvium	6			1



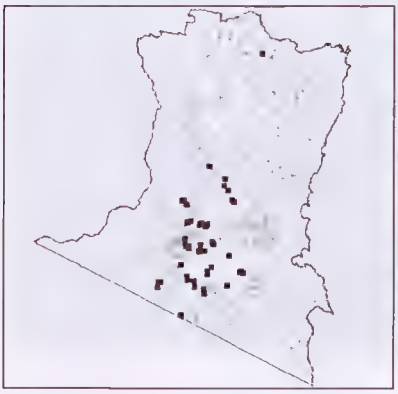
Map 30. Distribution of samples of Wallagaraugh Dry Grass Forest (Map Unit 30) shown by large black squares. Samples of other map units shown as small grey points.

Plate 30. Wallagaraugh Dry Shrub Forest (Map Unit 30) dominated by *Eucalyptus angophoroides, E. viminalis* and *E. ovata* with *Acacia longifolia, Lomandra longifolia, Poa meionectes* and *Gahnia sieberiana* on Walla Walla Creek, Waalimma section of South East Forests National Park.

Map Unit 31: Hinterland Dry Grass Forest

Hinterland Dry Grass Forest is dominated by *Eucalyptus globoidea* c. 25 m tall, and a variable compliment of other species, the most frequent of which are *E. angophoroides, E. cypellocarpa, E. maidenii* and *E. sieberi.* Scattered shrubs of *Leucopogon lanceolatus* emerge from a diverse, semi-continuous groundcover dominated by grasses and graminoids *Poa meionectes, Dichelachne rara, Microlaena stipoides, Lomandra longifolia* and *L. multiflora* with forbs including *Desmodium varians, Gonocarpus tetragynus, Hydrocotyle laxiflora, Hypericum gramineum, Viola hederacea, Gnaphalium gymnocephalum, Lagenifera stipitata, Senecio* sp. E and *Veronica calycina,* twiners of *Glycine clandestina* and bracken, *Pteridium esculentum.* Hinterland Dry Grass Forest is widespread in undulating granitoid terrain at 250–700 m elevation in the hinterland and foothills mainly south of the Bega valley. It generally occurs on drier sites than Nalbaugh Dry Grass Forest (Map Unit 29) and Wallagaraugh Dry Grass Forest (Map Unit 30) and differs in the composition of sub-dominant trees, its less developed shrub stratum and greater compliment of groundcover species. Its composition does not readily match any of the assemblages described in adjacent regions (Austin 1978, Forbes et al. 1982), however, there may be restricted occurrences within the Grassy Dry Forest complex in the foothills of East Gippsland (Woodgate et al. 1994). About 15% of Hinterland Dry Grass Forest has been cleared, but large areas remain on all tenures. Stands on private land are potentially threatened by further clearing. Frequent disturbance regimes that include logging (outside reserves) and fire in combination may reduce diversity by interrupting life-cycle processes of woody species (Keith 1996), changing the relative abundance of eucalypt species (Bridges 1983) and increasing rates of sedimentation. These impacts are most severe for assemblages with larger components of woody species and those more topographically restricted to lower slopes.

Species richness: 38 ± 1 (0.04 ha)
Extant area: 27 700 ha
Proportion cleared: 16%
Number of samples: 54



Map 31. Distribution of samples of Hinterland Dry Grass Forest (Map Unit 31) shown by large black squares. Samples of other map units shown as small grey points.

Plate 31. Hinterland Dry Grass Forest (Map Unit 31) dominated by *Eucalyptus angophoroides, E. cypellocarpa* and *E. globoidea* with *Poa meionectes* and numerous other grass and forb species on Nungatta Road east of Nungatta Creek, Waalimma section of South East Forests National Park.

Table 31a. Diagnostic plant species of Map Unit 31.

Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Desmodium varians	0.704	2(1–2)	0.233	1(1–2)	positive
Eucalyptus globoidea	0.833	3(1–3)	0.22	3(1–3)	positive
Gonocarpus tetragynus	0.574	2(1–2)	0.15	2(1–2)	positive
Hydrocotyle laxiflora	0.685	2(1–2)	0.188	1(1–2)	positive
Hypericum gramineum	0.833	2(1–2)	0.219	1(1–1)	positive
Leucopogon lanceolatus var. *lanceolatus*	0.667	2(1–2)	0.396	1(1–2)	positive
Senecio diaschides	0.019	1(1–1)	0	0(0–0)	positive
Viola hederacea subsp. *hederacea*	0.519	2(2–3)	0.434	2(1–2)	positive
Lomandra longifolia	0.852	2(1–2)	0.537	2(1–2)	frequent
Poa meionectes	0.833	3(2–4)	0.528	2(1–3)	frequent
Pteridium esculentum	0.611	2(2–3)	0.576	2(1–3)	frequent
Dichelachne rara	0.667	1(1–2)	0.151	1(1–2)	frequent
Glycine clandestina	0.741	1(1–2)	0.312	1(1–2)	frequent
Gnaphalium gymnocephalum	0.63	1(1–2)	0.166	1(1–1)	frequent
Lagenifera stipitata	0.63	1.5(1–2)	0.312	1(1–2)	frequent
Lomandra multiflora	0.611	1(1–2)	0.238	1(1–2)	frequent
Microlaena stipoides var. *stipoides*	0.648	1(1–2)	0.343	2(1–2)	frequent
Senecio sp. E	0.704	1(1–2)	0.174	1(1–1)	frequent
Veronica calycina	0.778	1(1–2)	0.183	1(1–1)	frequent
Eucalyptus agglomerata	0.111	2.5(2–3)	0.109	3(2–3)	uninformative
Eucalyptus angophoroides	0.333	3(1–3)	0.033	2(1–3)	uninformative
Eucalyptus baueriana	0.019	4(4–4)	0.027	2(1–3)	uninformative
Eucalyptus bosistoana	0.111	2.5(1–3)	0.051	2(1–3)	uninformative
Eucalyptus cypellocarpa	0.37	3(1–3)	0.312	3(2–3)	uninformative
Eucalyptus dives	0.037	2.5(2–3)	0.01	3(2–3)	uninformative
Eucalyptus elata	0.185	2.5(2–3)	0.11	3(2–3)	uninformative
Eucalyptus fastigata	0.019	3(3–3)	0.145	3(3–4)	uninformative
Eucalyptus maidenii	0.389	3(2–3)	0.051	3(2–3)	uninformative
Eucalyptus muelleriana	0.222	3(1–4)	0.139	3(3–4)	uninformative
Eucalyptus obliqua	0.019	2(2–2)	0.196	3(2–4)	uninformative
Eucalyptus polyanthemos subsp. *vestita*	0.13	3(3–3)	0.017	2(2–3)	uninformative
Eucalyptus radiata	0.185	3(1–3)	0.073	3(1–3)	uninformative
Eucalyptus sieberi	0.333	3(2–4)	0.281	3(2–4)	uninformative
Eucalyptus viminalis	0.148	3(1–3)	0.054	3(1–3)	uninformative

Table 31b. Vegetation structure of Map Unit 31. Frequency is the proportion of samples in which strata were present. Height and cover data are means with standard errors in parentheses (n=46).

Stratum	Frequency (%)	Height (m)	Cover (%)
Tree	100	25.1(0.9)	36(2)
Small tree	17.4	8.9(1.3)	11(2)
Shrub	95.7	2.1(0.2)	20(2)
Ground cover	100	0.5(0.0)	38(3)

Table 31c. Habitat characteristics of Map Unit 31. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5° and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		961	910–1010	54
Altitude (m)		510	396–605	54
Slope (degrees)		11	7–13	52
Terrain class				
North	38			20
Intermediate	37			19
South	17			9
Flat	8			4
Parent material				
Devonian granitoids	93			50
Low quartz sedimentaries	2			1
Ordovician high quartz sedimentaries	6			3

Map Unit 32: Coastal Foothills Dry Shrub Forest

Coastal Foothills Dry Shrub Forest has a variable tree stratum c. 25 m tall comprising *Eucalyptus longifolia* and *E. muelleriana* with *E. tricarpa, E. agglomerata, E. sieberi* and *Angophora floribunda* in various combinations. Other trees such as *Corymbia maculata* and *E. paniculata* may reach high abundance in some stands north of Bega. *Allocasuarina littoralis* may form an open subcanopy c. 12 m tall. An open shrub stratum is dominated by *Platysace lanceolata* with numerous low frequency species. The grassy groundcover is dominated by tussocks of *Chionochloa pallida* with scattered individuals of *Entolasia stricta* and *Lomandra multiflora.* Although confined to metamorphosed sediments and mudstones, Coastal Foothills Dry Shrub Forest is widespread on steep slopes and ridges at 50–250 m elevation on the coastal foothills north from Eden. About 5% of this unit has been cleared for small-scale rural development, but large areas remain on all tenures. Stands on private land are potentially threatened by further clearing with ongoing development of rural blocks. Frequent disturbance regimes that include logging (outside reserves) and fire in combination may reduce diversity by interrupting life-cycle processes of woody species (Keith 1996) and increasing erosion from the steep slopes in these habitats. Logging followed by regeneration burns and thinning may change the relative abundance of eucalypt species, particularly *E. sieberi* (Bridges 1983). Intervals between planned and unplanned disturbances need to be long enough to allow replenishment of seed banks and restoration of habitat structure if losses of diversity are to be avoided.

Species richness: 31 ± 2 (0.04 ha)
Extant area: 23 614 ha
Proportion cleared: 5%
Number of samples: 42

Table 32a. Diagnostic plant species of Map Unit 32.

Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Acacia irrorata ssp. *irrorata*	0.024	1(1–1)	0	0(0–0)	positive
Acacia mabellae	0.024	1(1–1)	0	0(0–0)	positive
Allocasuarina littoralis	0.762	3(1–4)	0.147	2(1–3)	positive
Chionochloa pallida	0.857	3(2–4)	0.083	2(1–3)	positive
Entolasia stricta	0.571	2(1–2)	0.17	1(1–2)	positive
Eucalyptus longifolia	0.548	3(2–3)	0.015	3(2–3)	positive
Eucalyptus muelleriana	0.524	3(2–3)	0.131	3(2–4)	positive
Eucalyptus paniculata	0.024	3(3–3)	0	0(0–0)	positive
Goodenia hederacea var. *hederacea*	0.024	1(1–1)	0	0(0–0)	positive
Melaleuca hypericifolia	0.024	2(2–2)	0	0(0–0)	positive
Ozothamnus obcordatus	0.024	1(1–1)	0	0(0–0)	positive
Platysace lanceolata	0.881	2(1–3)	0.233	2(1–2)	positive
Austrostipa verticillata	0.024	1(1–1)	0	0(0–0)	positive
Xanthosia atkinsoniana	0.024	1(1–1)	0	0(0–0)	positive
Lomandra multiflora	0.762	1(1–2)	0.236	1(1–2)	frequent
Acacia subporosa	0.024	2(2–2)	0.004	1.5(1–2)	uninformative
Angophora floribunda	0.5	1(1–2)	0.083	2(1–3)	uninformative
Backhousia myrtifolia	0.024	1(1–1)	0.002	3(1–4)	uninformative
Corymbia gummifera	0.167	4(3–4)	0.016	3(2–3)	uninformative
Corymbia maculata	0.095	3.5(2–5)	0.003	3.5(2–5)	uninformative
Eucalyptus agglomerata	0.452	3(1–3)	0.099	3(2–3)	uninformative
Eucalyptus bosistoana	0.095	1.5(1–3)	0.052	2(1–3)	uninformative
Eucalyptus botryoides	0.048	1.5(1–2)	0.01	2(1–3)	uninformative
Eucalyptus cypellocarpa	0.071	1(1–3)	0.321	3(2–3)	uninformative
Eucalyptus elata	0.048	1(1–1)	0.115	3(2–3)	uninformative
Eucalyptus globoidea	0.238	3(1–3)	0.243	3(1–3)	uninformative
Eucalyptus radiata	0.024	3(3–3)	0.078	3(1–3)	uninformative
Eucalyptus sieberi	0.333	1.5(1–3)	0.281	3(2–4)	uninformative
Eucalyptus smithii	0.095	1.5(1–3)	0.044	2(1–3)	uninformative
Eucalyptus tricarpa	0.452	2(1–3)	0.01	1.5(1–3)	uninformative
Lomandra longifolia	0.381	1(1–2)	0.554	2(1–2)	negative
Poa meionectes	0.476	2(1–2)	0.541	2(1–3)	negative
Pteridium esculentum	0.214	2(1–3)	0.587	2(1–3)	negative

Table 32b. Vegetation structure of Map Unit 32. Frequency is the proportion of samples in which strata were present. Height and cover data are means with standard errors in parentheses (n=35).

Stratum	Frequency (%)	Height (m)	Cover (%)
Tree	100	25.0(0.9)	30(2)
Small tree	68.6	11.5(0.7)	18(2)
Shrub	100	2.1(0.2)	22(3)
Ground cover	100	0.5(0.0)	36(5)

Table 32c. Habitat characteristics of Map Unit 32. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5° and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		917	883–949	42
Altitude (m)		129	93–160	42
Slope (degrees)		15	8–20	41
Terrain class				
North	34			14
Intermediate	44			18
South	10			4
Flat	12			5
Parent material				
Devonian granitoids	2			1
Devonian high quartz sedimentaries	19			8
Low quartz sedimentaries	14			6
Ordovician high quartz sedimentaries	64			27

Map 32. Distribution of samples of Coastal Foothills Dry Shrub Forest (Map Unit 32) shown by large black squares. Samples of other map units shown as small grey points.

Plate 32. Coastal Foothills Dry Shrub Forest (Map Unit 32) dominated by *Eucalyptus tricarpa, E. longifolia* and *E. bosistoana* with *Acacia falciformis, Daviesia mimosoides* and *Chionochloa pallida* on Goats Knob Road, southern section of Mimosa Rocks National Park.

Map Unit 33: Coastal Range Dry Shrub Forest

Coastal Range Dry Shrub Forest is dominated by *Eucalyptus muelleriana* c. 25 m tall, occasionally with *E. cypellocarpa, E. agglomerata, E. sieberi* or *E. smithii. Acacia falciformis, Cassinia longifolia* and *Persoonia linearis* dominate a prominent stratum of shrubs 2–8 m tall, while the species-poor groundcover includes scattered individuals of *Poa meionectes, Lomandra longifolia, L. multiflora* and *Lepidosperma laterale.* Coastal Range Dry Shrub Forest is widespread on dry to intermediate slopes of the coastal and hinterland ranges south of Bega, primarily on metasediments at 100–600 m elevation. It often occupies drier slopes adjacent to gullies with Hinterland Wet Shrub Forest (Map Unit 14) or Coastal Gully Shrub Forest (Map Unit 34). Its distribution extends to higher elevations and further south than Coastal Foothills Dry Shrub Forest (Map Unit

32). No similar assemblages have been described outside the Eden region (Austin 1978, Forbes et al. 1982). Most of this assemblage occurs on public land and very little has been cleared. The principal threat is frequent disturbance regimes that include logging (outside reserves) and fire in combination. These may reduce diversity by interrupting life-cycle processes of woody species (Keith 1996) and increasing erosion from the steep slopes in these habitats. Logging followed by regeneration burns and thinning may change the relative abundance of eucalypt species, particularly *E. sieberi* (Bridges 1983). Intervals between planned and unplanned disturbances need to be long enough to allow replenishment of seed banks and restoration of habitat structure if losses of diversity are to be avoided.

Species richness: 27 ± 1 (0.04 ha)
Extant area: 16 336 ha
Proportion cleared: 1%
Number of samples: 55

Table 33a. Diagnostic plant species of Map Unit 33.

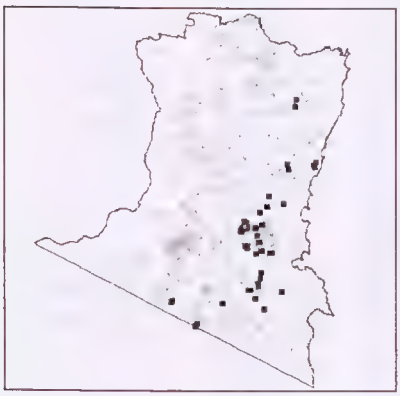
Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Acacia falciformis	0.746	2(1–3)	0.168	2(1–3)	positive
Eucalyptus muelleriana	0.855	3(3–4)	0.114	3(2–4)	positive
Pimelea humilis	0.018	2(2–2)	0	0(0–0)	positive
Zieria arborescens	0.018	1(1–1)	0	0(0–0)	positive
Lomandra longifolia	0.582	2(1–2)	0.548	2(1–2)	frequent
Poa meionectes	0.764	2(1–3)	0.53	2(1–3)	frequent
Cassinia longifolia	0.655	1(1–2)	0.17	1(1–3)	frequent
Lomandra multiflora	0.6	1(1–2)	0.238	1(1–2)	frequent
Acacia subporosa	0.018	1(1–1)	0.004	2(1–2)	uninformative
Angophora floribunda	0.018	1(1–1)	0.098	2(1–3)	uninformative
Corymbia gummifera	0.036	2(2–2)	0.02	3(2–4)	uninformative
Eucalyptus agglomerata	0.291	2.5(2–3)	0.102	3(2–3)	uninformative
Eucalyptus baueriana	0.018	3(3–3)	0.027	2(1–3)	uninformative
Eucalyptus bosistoana	0.146	2(2–3)	0.049	2(1–3)	uninformative
Eucalyptus consideniana	0.018	2(2–2)	0.021	2(1–3)	uninformative
Eucalyptus cypellocarpa	0.327	3(2–3)	0.313	3(2–3)	uninformative
Eucalyptus elata	0.036	3.5(3–4)	0.116	3(2–3)	uninformative
Eucalyptus fastigata	0.018	3(3–3)	0.145	3(3–4)	uninformative
Eucalyptus globoidea	0.164	3(3–3)	0.246	3(1–3)	uninformative
Eucalyptus longifolia	0.073	2(1–2)	0.028	3(2–3)	uninformative
Eucalyptus polyanthemos subsp. *vestita*	0.073	2(2–2)	0.011	3(2–3)	uninformative
Eucalyptus sieberi	0.436	3(1–4)	0.277	3(2–4)	uninformative
Eucalyptus smithii	0.273	3(1–3)	0.037	2(1–3)	uninformative
Eucalyptus tricarpa	0.146	1.5(1–3)	0.018	2(1–3)	uninformative
Lepidosperma laterale	0.564	1(1–2)	0.336	1(1–2)	uninformative
Persoonia linearis	0.509	1(1–2)	0.277	1(1–2)	uninformative
Pteridium esculentum	0.382	2(1–2)	0.584	2(1–3)	negative

Table 33b. Vegetation structure of Map Unit 33. Frequency is the proportion of samples in which strata were present. Height and cover data are means with standard errors in parentheses (n=25).

Stratum	Frequency (%)	Height (m)	Cover (%)
Tree	100	25.6(1.2)	35(3)
Small tree	60	9.2(0.8)	24(4)
Shrub	100	1.9(0.2)	25(4)
Ground cover	100	0.5(0.1)	19(3)

Table 33c. Habitat characteristics of Map Unit 33. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5° and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		938	888–967	55
Altitude (m)		333	254–398	42
Slope (degrees)		17	10–22	39
Terrain class				
North	38			15
Intermediate	49			19
South	3			1
Flat	10			4
Parent material				
Devonian granitoids	15			8
Devonian high quartz sedimentaries	42			23
Low quartz sedimentaries	5			3
Ordovician high quartz sedimentaries	38			21



Map 33. Distribution of samples of Coastal Range Dry Shrub Forest (Map Unit 33) shown by large black squares. Samples of other map units shown as small grey points.

Plate 33. Coastal Range Dry Shrub Forest (Map Unit 33) dominated by *Eucalyptus muelleriana* and *E. sieberi* with tall shrubs of *Acacia cognata* and scattered *Goodenia ovata* and *Poa meionectes* on the footslopes of Mt Imlay, south-west of Eden. Note dead eucalypt stag with hollows on right.

Map Unit 34: Coastal Gully Shrub Forest

Coastal Gully Shrub Forest has a very variable tree stratum including *Eucalyptus bosistoana, E. cypellocarpa, E. globoidea, E. longifolia* and *E. muelleriana* in various combinations and reaching heights of up to 30 m. A open small tree stratum c. 10 m tall includes *Acacia mearnsii, Pittosporum undulatum* and several rainforest elements. The distinctive and diverse mesophyllous shrub stratum includes *Citriobatus pauciflorus, Goodenia ovata, Hibbertia aspera, Pimelea axiflora, Notelaea venosa* and *Ozothamnus diosmifolius*. The species-rich groundcover includes a variety of grasses and graminoids including *Entolasia stricta, Microlaena stipoides, Oplismenus imbecillus, Poa meionectes, Lomandra longifolia* and *Lepidosperma laterale*, and forbs *Desmodium varians, Dichondra repens* and *Pratia purpurascens*. A diverse compliment of vines entangles the shrub and ground strata including *Glycine clandestina, Marsdenia rostrata,*

Eustrephus latifolius, Geitonoplesium cymosum and *Pandorea pandorana*. Coastal Gully Shrub Forest occurs in steep gullies on the coastal range mainly north of Merimbula, often co-occurring with Coastal Foothills Dry Shrub Forest (Map Unit 32), which occupies adjacent upper slopes. It is restricted to metasediments below 200 m elevation. Similar assemblages are likely to extend further north where rugged sedimentary terrain is close to the coast (Austin 1978). Substantial areas of this assemblage remain on all tenures, slightly more than 13% being cleared. About 5000 ha is potentially threatened by development of small rural holdings on private land. Frequent disturbance regimes that include logging (outside reserves) and fire in combination may reduce diversity by interrupting life-cycle processes of woody species and increasing erosion on the steep slopes in these habitats. Intervals between planned and unplanned disturbances need to be long enough to allow replenishment of seed banks and restoration of habitat structure if high levels of diversity are to be maintained in this species-rich assemblage.

Species richness: 46 ± 3 (0.04 ha)
Extant area: 15 289 ha
Proportion cleared: 13%
Number of samples: 24

Table 34a. Diagnostic plant species of Map Unit 34.

Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Acacia mearnsii	0.667	2(1–3)	0.155	2(1–3)	positive
Citriobatus pauciflorus	0.125	1(1–2)	0	0(0–0)	positive
Desmodium varians	0.667	2(1–2)	0.243	1(1–2)	positive
Dichondra repens	0.833	2(1–2)	0.275	2(1–2)	positive
Doodia caudata var. *caudata*	0.042	1(1–1)	0	0(0–0)	positive
Entolasia stricta	0.667	2(2–3)	0.173	1(1–2)	positive
Glycine clandestina	0.792	2(1–2)	0.32	1(1–2)	positive
Goodenia ovata	0.75	2(1–2)	0.164	2(1–2)	positive
Hibbertia aspera	0.542	2(2–2)	0.06	2(1–2)	positive
Marsdenia rostrata	0.625	2(1–2)	0.077	2(1–2)	positive
Microlaena stipoides var. *stipoides*	0.708	2(1–2)	0.348	1.5(1–2)	positive
Muellerina celastroides	0.042	1(1–1)	0	0(0–0)	positive
Oplismenus imbecillis	0.833	2(1–2)	0.097	2(1–2)	positive
Pimelea axiflora	0.5	2(2–3)	0.113	1(1–2)	positive
Pittosporum undulatum	0.625	2(1–3)	0.083	1(1–2)	positive
Sarcochilus hillii	0.042	1(1–1)	0	0(0–0)	positive
Zieria cytisoides	0.042	2(2–2)	0	0(0–0)	positive
Zieria littoralis	0.042	1(1–1)	0	0(0–0)	positive
Poa meionectes	0.75	2(1–3)	0.535	2(1–3)	frequent
Eustrephus latifolius	0.917	1(1–1)	0.162	1(1–1)	frequent
Gahnia melanocarpa	0.625	1(1–2)	0.066	1(1–2)	frequent
Geitonoplesium cymosum	0.75	1(1–2)	0.099	1(1–2)	frequent
Lepidosperma laterale	0.667	1(1–2)	0.339	1(1–2)	frequent
Lomandra longifolia	0.833	1(1–1)	0.544	2(1–2)	frequent
Notelaea venosa	0.75	1(1–2)	0.103	1(1–2)	frequent
Ozothamnus diosmifolius	0.625	1(1–3)	0.07	1(1–2)	frequent
Pandorea pandorana	0.625	1(1–2)	0.113	1(1–1)	frequent
Pratia purpurascens	0.667	1(1–2)	0.094	1(1–2)	frequent
Acacia silvestris	0.083	2.5(1–4)	0.002	5(4–5)	uninformative

Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Acmena smithii	0.042	1(1–1)	0.032	3(1–4)	uninformative
Alectryon subcinereus	0.083	1(1–1)	0.006	1(1–3)	uninformative
Angophora floribunda	0.292	3(1–3)	0.092	2(1–3)	uninformative
Backhousia myrtifolia	0.042	4(4–4)	0.002	1(1–3)	uninformative
Eucalyptus baueriana	0.083	3(2–4)	0.026	2(1–3)	uninformative
Eucalyptus bosistoana	0.333	2(1–3)	0.048	2(1–3)	uninformative
Eucalyptus cypellocarpa	0.375	3(1–4)	0.313	3(2–3)	uninformative
Eucalyptus elata	0.25	2.5(2–3)	0.111	3(2–3)	uninformative
Eucalyptus globoidea	0.333	3(1–3)	0.241	3(1–3)	uninformative
Eucalyptus longifolia	0.417	2.5(1–3)	0.023	3(2–3)	uninformative
Eucalyptus muelleriana	0.375	3(1–3)	0.138	3(3–4)	uninformative
Eucalyptus pilularis	0.042	1(1–1)	0.003	3.5(2–4)	uninformative
Eucalyptus smithii	0.042	1(1–1)	0.046	2(1–3)	uninformative
Eucalyptus tricarpa	0.042	1(1–1)	0.022	2(1–3)	uninformative
Pteridium esculentum	0.417	2(1–4)	0.579	2(1–3)	negative

Table 34b. Vegetation structure of Map Unit 34. Frequency is the proportion of samples in which strata were present. Height and cover data are means with standard errors in parentheses (n=22).

Stratum	Frequency (%)	Height (m)	Cover (%)
Tree	100	28.0(1.5)	36(2)
Small tree	86.4	10.3(1.0)	25(4)
Shrub	100	2.8(0.5)	25(3)
Ground cover	100	0.6(0.1)	40(6)

Map 34. Distribution of samples of Coastal Gully Shrub Forest (Map Unit 34) shown by large black squares. Samples of other map units shown as small grey points.

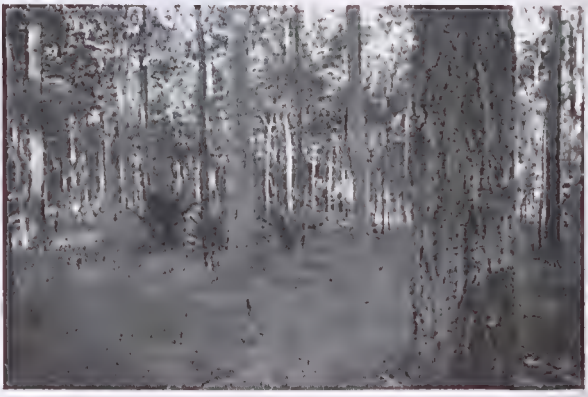


Plate 34. Coastal Range Dry Shrub Forest (Map Unit 34) variant dominated by *Eucalyptus paniculata, Corymbia maculata* and *Macozamia communis* with a diverse grassy groundcover, west of Bermagui in Bermagui State Forest.

Table 34c. Habitat characteristics of Map Unit 34. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5° and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		911	881–938	24
Altitude (m)		95	40–165	24

Slope (degrees)		16	10–23	24
Terrain class				
North	17			4
Intermediate	38			9
South	38			9
Flat	8			2
Parent material				
Devonian high quartz sedimentaries	4			1
Low quartz sedimentaries	8			2
Ordovician high quartz sedimentaries	88			21

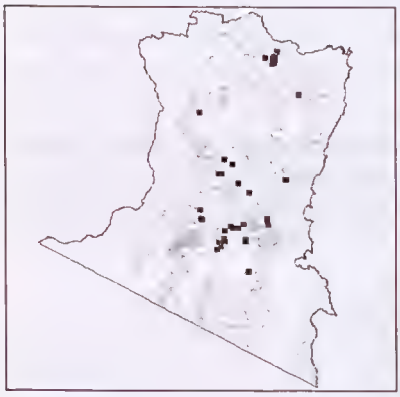
Map Unit 35: Escarpment Dry Grass Forest

Escarpment Dry Grass Forest is dominated by *Eucalyptus maidenii* and *E. globoidea,* occasionally with *E. bosistoana* over 25 m tall. *Indigofera australis* and *Senecio linearifolius* dominate an open stratum of mesophyllous shrubs with less frequent species including *Cassinia* spp. and *Ozothamnus diosmifolius,* while the diverse grassy groundcover is dominated by *Poa meionectes, Microlaena stipoides* and *Lomandra longifolia,* forbs *Plectranthus parviflorus, Desmodium varians* and *Dichondra repens,* and the twiner *Glycine clandestina.* Escarpment Dry Grass Forest occurs at 150–700 m elevation on steep to moderate, dry granitoid slopes surrounding the Bega and Towamba valleys. Unusual stands occur on small basalt outcrops west of Nethercote. In the Murrabrine area and on the Bega valley escarpment, it is interspersed with Hinterland Wet Fern Forest (Map Unit 13), which occupies more sheltered mesic sites. South of Wyndham, it occurs in hilly terrain interspersed with Bega Wet Shrub Forest (Map Unit 19) on low relief sites. While this unit may extend a short distance further north in the Yowrie district, no similar assemblages have been described outside the Eden region (Austin 1978, Forbes et al. 1982). Approximately one-third of Escarpment Dry Grass Forest has been cleared for agriculture and over half of the remainder occurs on private land (mainly on toeslopes and foothills of the escarpment) where it is potentially threatened by further clearing. Soil erosion is a potential threat associated with logging, although in some cases this will be restricted to indirect effects from operations upslope because steep slopes may preclude direct timber harvesting within stands of this assemblage. Frequent burning around the interface of private and public land may also be a threat to some stands of Escarpment Dry Grass Forest. This may reduce diversity by interrupting life-cycle processes of woody species (Keith 1996) and increasing erosion from the steep slopes in these habitats. Intervals between planned and unplanned disturbances need to be long enough to allow replenishment of seed banks and restoration of habitat structure if losses of diversity are to be avoided.

Species richness: 37 ± 1 (0.04 ha)
Extant area: 24 423 ha
Proportion cleared: 37%
Number of samples: 51

Table 35a. Diagnostic plant species of Map Unit 35.

Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Chenopodium carinatum	0.039	1(1–1)	0	0(0–0)	positive
Desmodium varians	0.863	2(2–2)	0.228	1(1–2)	positive
Dichondra repens	0.784	2(1–2)	0.266	1.5(1–2)	positive
Eucalyptus globoidea	0.588	3(2–3)	0.23	3(1–3)	positive
Eucalyptus maidenii	0.824	3(3–4)	0.036	3(2–3)	positive
Indigofera australis	0.608	2(2–3)	0.089	1(1–2)	positive
Plectranthus parviflorus	0.588	2(1–2)	0.039	1(1–2)	positive
Senecio linearifolius	0.608	2(1–3)	0.227	1(1–2)	positive
Austrostipa scabra	0.02	1(1–1)	0	0(0–0)	positive
Poa meionectes	0.667	3(2–3)	0.534	2(1–3)	frequent
Glycine clandestina	0.863	1(1–2)	0.308	1(1–2)	frequent
Lomandra longifolia	0.706	1(1–2)	0.543	2(1–2)	frequent
Microlaena stipoides var. *stipoides*	0.686	1(1–2)	0.342	2(1–2)	frequent
Acmena smithii	0.02	1(1–1)	0.032	3(1–4)	uninformative
Alectryon subcinereus	0.02	1(1–1)	0.007	1(1–2)	uninformative
Brachychiton populneus subsp. *populneus*	0.137	1(1–1)	0.019	1(1–1)	uninformative
Eucalyptus agglomerata	0.02	3(3–3)	0.112	3(2–3)	uninformative
Eucalyptus angophoroides	0.039	2(1–3)	0.044	2(1–3)	uninformative
Eucalyptus baueriana	0.216	2(2–3)	0.02	2.5(1–4)	uninformative
Eucalyptus bosistoana	0.392	3(2–3)	0.041	2(1–3)	uninformative
Eucalyptus cypellocarpa	0.137	1(1–2)	0.32	3(2–3)	uninformative
Eucalyptus elata	0.255	3(2–3)	0.108	3(1–3)	uninformative
Eucalyptus fastigata	0.118	2(2–3)	0.141	3(3–4)	uninformative
Eucalyptus muelleriana	0.294	3(2–3)	0.137	3(2–4)	uninformative
Eucalyptus polyanthemos subsp. *vestita*	0.137	1(1–2)	0.01	2(2–3)	uninformative
Eucalyptus sieberi	0.078	2.5(2–4)	0.29	3(2–4)	uninformative
Eucalyptus smithii	0.118	2(2–3)	0.043	2(1–3)	uninformative
Eucalyptus tereticornis	0.02	3(3–3)	0.048	3(1–3)	uninformative
Eucalyptus tricarpa	0.02	1(1–1)	0.023	2(1–3)	uninformative
Pteridium esculentum	0.314	1.5(1–2)	0.586	2(1–3)	negative



Map 35. Distribution of samples of Escarpment Dry Grass Forest (Map Unit 35) shown by large black squares. Samples of other map units shown as small grey points.

Plate 35. Coastal Range Dry Shrub Forest (Map Unit 35) dominated by *Eucalyptus maidenii* and *E. bosistoana* saplings with *Indigofera australis*, *Acacia falciformis* and *Poa meionectes* on the dry lower slopes of the Brown Mountain escarpment, Tantawangalo section of South East Forests National Park.

Table 35b. Vegetation structure of Map Unit 35. Frequency is the proportion of samples in which strata were present. Height and cover data are means with standard errors in parentheses (n=24).

Stratum	Frequency (%)	Height (m)	Cover (%)
Tree	100	27.4(1.3)	31(2)
Small tree	50	8.8(0.9)	21(3)
Shrub	100	2.0(0.2)	21(3)
Ground cover	100	0.4(0.0)	30(6)

Table 35c. Habitat characteristics of Map Unit 35. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5°and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		938	873–1010	51
Altitude (m)		400	320–485	51
Slope (degrees)		15	10–20	36
Terrain class				
North	33			12
Intermediate	47			17
South	8			3
Flat	11			4
Parent material				
Devonian Basalt	4			2
Devonian granitoids	75			38
Low quartz sedimentaries	2			1
Ordovician high quartz sedimentaries	20			10

Map Unit 36: Dune Dry Shrub Forest

Dune Dry Shrub Forest is dominated by *Eucalyptus botryoides* c. 10 m tall. A prominent stratum of small trees and large shrubs includes *Banksia integrifolia, B. serrata* and *Monotoca elliptica*. Smaller shrubs include *Astroloma pinifolium, Macrozamia communis, Acacia sophorae, Correa reflexa* and *Hibbertia obtusifolia*. The groundcover includes grasses and graminoids *Lomandra longifolia, Poa meionectes, Themeda australis* and *Imperata cylindrica,* forbs *Dichondra repens* and *Pratia purpurascens,* and bracken *Pteridium esculentum*. Dune Dry Shrub Forest is restricted to sheltered slopes and flats on well-drained calcareous sand dunes and adjacent metasediments within a few hundred metres of the coast north from Merimbula. A similar assemblage is scattered along the coast of East Gippsland (Community 19.1, Forbes et al. 1982). Similar vegetation is also likely to be found in near-coastal habitats north of the Eden region. Two-thirds of this restricted unit has been cleared for coastal development and almost half of the remaining 600 ha occurs on private land or special crown tenures threatened by further clearing. Because of their close proximity to urban settlement and/or high levels of recreational usage, remnants of Dune Dry Shrub Forest are exposed to continuing degradation associated with rubbish dumping, frequent burning, erosion, nutrification and weed invasion. These threats apply throughout the range of this vegetation, although impacts are mitigated by management to varying degrees in reserved stands.

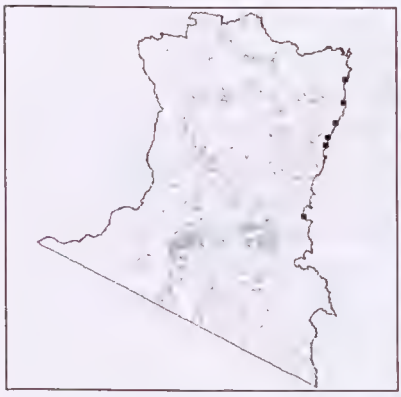
Species richness: 22 ± 2 (0.04 ha)
Extant area: 646 ha
Proportion cleared: 39%
Number of samples: 6

Table 36a. Diagnostic plant species of Map Unit 36.

Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Astroloma pinifolium	0.167	1(1–1)	0	0(0–0)	positive
Banksia serrata	0.5	2(1–3)	0.04	1(1–2)	positive
Banksia integrifolia	1	1(1–2)	0.031	1(1–2)	frequent
Dichondra repens	0.667	1(1–1)	0.282	2(1–2)	frequent
Eucalyptus botryoides	0.667	1.5(1–4)	0.009	2(1–3)	frequent
Lomandra longifolia	0.667	1(1–1)	0.548	2(1–2)	frequent
Macrozamia communis	0.667	1.5(1–3)	0.011	1.5(1–2)	frequent
Monotoca elliptica	1	1(1–1)	0.017	1(1–1)	frequent
Poa meionectes	0.667	1(1–1)	0.538	2(1–3)	frequent
Pratia purpurascens	0.667	1(1–1)	0.101	1(1–2)	frequent
Pteridium esculentum	1	1(1–3)	0.575	2(1–3)	frequent
Themeda australis	0.667	1.5(1–2)	0.112	2(1–3)	frequent
Acacia sophorae	0.5	1(1–1)	0.033	1(1–2)	uninformative
Correa reflexa	0.5	1(1–1)	0.126	1(1–2)	uninformative
Corymbia maculata	0.167	2(2–2)	0.005	4(3–5)	uninformative
Eucalyptus tereticornis	0.167	2(2–2)	0.046	3(1–3)	uninformative
Hibbertia obtusifolia	0.5	1(1–1)	0.085	1(1–2)	uninformative
Imperata cylindrica var. *major*	0.5	1(1–1)	0.051	1(1–2)	uninformative

Table 36b. Vegetation structure of Map Unit 36. Frequency is the proportion of samples in which strata were present. Height and cover data are means with standard errors in parentheses (n=1).

Stratum	Frequency (%)	Height (m)	Cover (%)
Tree	100	10.0(-)	45(-)
Small tree	0	-(-)	-(-)
Shrub	100	1.0(-)	15(-)
Ground cover	100	0.5(-)	90(-)



Map 36. Distribution of samples of Dune Dry Shrub Forest (Map Unit 36) shown by large black squares. Samples of other map units shown as small grey points.

Plate 36. Dune Dry Shrub Forest (Map Unit 36) dominated by *Eucalyptus botryoides with Banksia serrata, B. integrifolia* and *Pteridium esculentum* behind Baragoot Beach, south of Bermagui.

Table 36c. Habitat characteristics of Map Unit 36. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5° and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		724	851–876	6
Altitude (m)		8	5–5	6
Slope (degrees)		2	2–2	1
Terrain class				
North	0			0
Intermediate	0			0
South	0			0
Flat	100			1
Parent material				
Holocene Coastal Sands	100			6

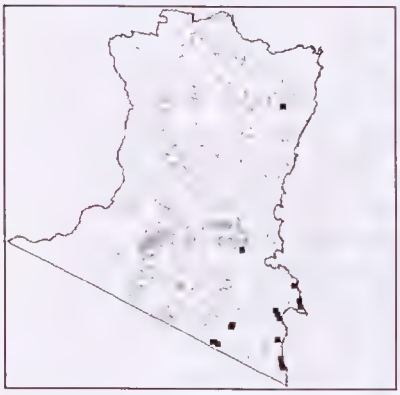
Map Unit 37: Lowland Gully Shrub Forest

Lowland Gully Shrub Forest is dominated by *Angophora floribunda* up to 25 m in height with *Eucalyptus cypellocarpa,* and occasionally *E. baxteri* and *E. globoidea.* One or two prominent tall shrub strata 5–8 m tall are dominated by *Acacia longifolia* and *Allocasuarina littoralis,* with smaller shrubs including *Goodenia ovata* and *Hibbertia aspera.* The tall semi-continuous groundcover is dominated by bracken *Pteridium esculentum* and grasses and graminoids *Lomandra longifolia, Entolasia stricta* and *Poa meionectes,* with other herbs including *Dianella caerulea, Gonocarpus teucrioides, Viola hederacea* and the twiner *Glycine clandestina.* Lowland Gully Shrub Forest occurs on gully flats either on Tertiary alluvium, Holocene sands or on deep colluvial sandy soils washed down from adjacent sedimentary substrates upslope. It is most common in the Nadgee-Timbillica area below 100 m elevation and includes the well-known Monkey Gum flats in that area. These flats provide important resource-rich fauna habitat with dense groundcover in an area largely covered by open dry sclerophyllous forests. Lowland Gully Shrub Forest has affinities with a highly restricted assemblage in similar habitats in far East Gippsland (Ecological Vegetation Class 4, Woodgate et al. 1994), but this unit has *E. botryoides* as a co-dominant tree and a greater diversity of vines. Similar vegetation is unlikely to occur north of the Eden region. Relatively little of this vegetation has been cleared. Although some stands on private land are potentially threatened by clearing, the principal threat is frequent disturbance regimes. In some unprotected sites with *E. cypellocarpa* the disturbance regime may include logging, although *A. floribunda* is not an economic wood species and some flats in production forest are protected by management prescriptions. Sedimentation may affect stands where logging occurs upslope. Where logging is carried out and followed by regeneration burns and thinning, this may change the relative abundance of eucalypt species, particularly *E. sieberi* (Bridges 1983). Frequent burning may reduce diversity by interrupting life-cycle processes of woody species and by competitive exclusion due to increased densities of *P. esculentum* and *I. cylindrica* (Keith 1996). Intervals between planned and unplanned disturbances need to be long enough to allow replenishment of seed banks, decline in densities of rhizomatous species and restoration of habitat structure if losses of diversity are to be avoided.

Species richness: 35± 2 (0.04 ha)
Extant area: 14 685 ha
Proportion cleared: 5%
Number of samples: 17

Table 37a. Diagnostic plant species of Map Unit 37.

Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Acacia longifolia	0.647	3(2–3)	0.135	2(1–3)	positive
Allocasuarina littoralis	0.529	2(1–3)	0.16	2(1–3)	positive
Angophora floribunda	0.824	3(3–4)	0.087	2(1–3)	positive
Dianella caerulea	0.706	2(1–2)	0.274	1(1–2)	positive
Entolasia stricta	0.588	2(2–3)	0.177	1(1–2)	positive
Eucalyptus pseudoglobulus	0.059	3(3–3)	0	0(0–0)	positive
Gonocarpus teucrioides	0.529	2(1–3)	0.313	2(1–2)	positive
Goodenia ovata	0.706	3(2–4)	0.167	2(1–2)	positive
Hibbertia aspera	0.529	2(2–3)	0.063	2(1–2)	positive
Viola hederacea subsp. *hederacea*	0.706	2(1–2)	0.434	2(1–2)	positive
Lomandra longifolia	0.824	3(2–4)	0.546	2(1–2)	frequent
Poa meionectes	0.882	2(2–3)	0.535	2(1–3)	frequent
Pteridium esculentum	0.882	3(2–4)	0.573	2(1–3)	frequent
Glycine clandestina	0.706	1(1–2)	0.323	1(1–2)	frequent
Corymbia gummifera	0.059	3(3–3)	0.02	3(2–4)	uninformative
Eucalyptus angophoroides	0.059	4(4–4)	0.044	2(1–3)	uninformative
Eucalyptus baxteri	0.294	3(2–4)	0.005	3(2–3)	uninformative
Eucalyptus cypellocarpa	0.412	1(1–4)	0.313	3(2–3)	uninformative
Eucalyptus elata	0.059	1(1–1)	0.113	3(2–3)	uninformative
Eucalyptus globoidea	0.235	2.5(1–4)	0.243	3(1–3)	uninformative
Eucalyptus longifolia	0.177	3(3–3)	0.028	3(2–3)	uninformative
Eucalyptus muelleriana	0.118	3.5(3–4)	0.142	3(2–4)	uninformative
Eucalyptus obliqua	0.118	2.5(1–4)	0.19	3(2–4)	uninformative
Eucalyptus ovata	0.177	3(3–3)	0.021	2(1–3)	uninformative
Eucalyptus sieberi	0.118	3(2–4)	0.285	3(2–4)	uninformative
Eucalyptus smithii	0.059	1(1–1)	0.045	2(1–3)	uninformative



Map 37. Distribution of samples of Lowland Gully Shrub Forest (Map Unit 37) shown by large black squares. Samples of other map units shown as small grey points.

Plate 37. Lowland Gully Shrub Forest (Map Unit 37) dominated by *Angophora floribunda* with *Eucalyptus cypellocarpa, Acacia longifolia, A. mearnsii, Pteridium esculentum* and *Microlaena stipoides* at Saltwater Creek flat, Ben Boyd National Park.

Table 37b. Vegetation structure of Map Unit 37. Frequency is the proportion of samples in which strata were present. Height and cover data are means with standard errors in parentheses (n=15).

Stratum	Frequency (%)	Height (m)	Cover (%)
Tree	100	23.3(2.2)	42(3)
Small tree	33.3	7.8(0.7)	37(9)
Shrub	100	5.0(2.2)	40(7)
Ground cover	100	1.1(0.2)	65(7)

Table 37c. Habitat characteristics of Map Unit 37. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5° and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		899	881–917	17
Altitude (m)		71	15–120	17
Slope (degrees)		5	2–6	16
Terrain class				
North	6			1
Intermediate	13			2
South	25			4
Flat	56			9
Parent material				
Devonian high quartz sedimentaries	6			1
Holocene Coastal Sands	18			3
Low quartz sedimentaries	6			1
Ordovician high quartz sedimentaries	24			4
Tertiary Alluvium	47			8

Map Unit 38: Southern Riparian Scrub

Southern Riparian Scrub has a patchy shrub stratum 2 m tall, dominated by *Tristaniopsis laurina, Acacia floribunda, Baeckea virgata, Calytrix tetragona, Kunzea ericoides, Leptospermum lanigerum* and *L. scoparium*, occasionally with emergent saplings of *Eucalyptus elata* c. 8 m tall. The patchy groundcover is dominated by rushes and sedges *Lomandra longifolia* and *Gahnia sieberiana*, with small ferns, *Adiantum aethiopicum*. Southern Riparian Scrub is restricted to riverine alluvium derived from granitoid or sedimentary parent materials at elevations up to 400 m along major streams in the south, including the Genoa, Wallagaraugh and Merrica Rivers, and possibly parts of the Towamba River. Although not explicitly described, similar vegetation may occur in East Gippsland within the riparian scrub complex (Ecological Vegetation Class 17, Woodgate et al. 1994), which also includes assemblages related to Lowland Swamp (Map Unit 57) and Swamp Forest (Map Unit 58). The principal threat to Southern Riparian Scrub is from sedimentation and weed invasion associated with roading and logging activities in stream catchments. Mitigation measures include stream buffer strips of varying width and erosion control during earthworks and logging. Frequent fire regimes may reduce diversity by interrupting life-cycle processes of woody species if streams are used repeatedly as ignition lines for hazard reduction.

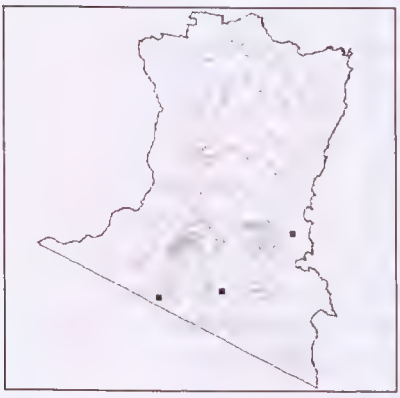
Species richness: 22 ± 14 (0.04 ha)
Extant area: 441 ha
Proportion cleared: 10%
Number of samples: 3

Table 38a. Diagnostic plant species of Map Unit 38.

Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Acacia floribunda	0.667	2.5(2–3)	0.016	2(1–3)	positive
Baeckea virgata	0.667	2(1–3)	0.029	2(1–2)	positive
Calytrix tetragona	0.667	2(1–3)	0.004	2.5(2–3)	positive
Grevillea linearifolia form 'g'	0.333	3(3–3)	0	0(0–0)	positive
Kunzea ericoides	0.667	2(2–2)	0.043	2(1–3)	positive
Leptospermum lanigerum	0.667	3(3–3)	0.007	2(1–3)	positive
Leptospermum scoparium	0.667	2(1–3)	0.016	2(1–3)	positive
Tristaniopsis laurina	1	4(3–5)	0.001	1.5(1–2)	positive
Utricularia lateriflora	0.333	1(1–1)	0	0(0–0)	positive
Vallisneria gigantea	0.333	1(1–1)	0	0(0–0)	positive
Lomandra longifolia	0.667	3.5(3–4)	0.549	2(1–2)	frequent
Adiantum aethiopicum	0.667	1(1–1)	0.076	1(1–2)	frequent
Gahnia sieberiana	0.667	1(1–1)	0.076	1(1–2)	frequent
Eucalyptus elata	0.333	1(1–1)	0.112	3(2–3)	uninformative
Poa meionectes	0	0(2–0)	0.54	2(1–3)	negative
Pteridium esculentum	0.333	1(1–1)	0.577	2(1–3)	negative

Table 38b. Vegetation structure of Map Unit 38. Frequency is the proportion of samples in which strata were present. Height and cover data are means with standard errors in parentheses (n=3).

Stratum	Frequency (%)	Height (m)	Cover (%)
Tree	0	-(-)	-(-)
Small tree	66.7	8.5(3.5)	25(15)
Shrub	100	2.0(0.3)	37(18)
Ground cover	100	0.5(0.0)	18(7)



Map 38. Distribution of samples of Southern Riparian Scrub (Map Unit 38) shown by large black squares. Samples of other map units shown as small grey points.

Plate 38. Southern Riparian Scrub (Map Unit 38) with *Callistemon subulatus, Acacia floribunda, Calytrix tetragona* and *Lomandra longifolia* among granitoid outcrops in the bed of Imlay Creek near Imlay Road crossing, Wallagaraugh Flora Reserve.

Table 38c. Habitat characteristics of Map Unit 38. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5° and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		921	904–949	3
Altitude (m)		235	168–348	3
Slope (degrees)		0	0–0	3
Terrain class				
North	0			0
Intermediate	0			0
South	0			0
Flat	100			3
Parent material				
Devonian granitoids	67			2
Tertiary Alluvium	33			1

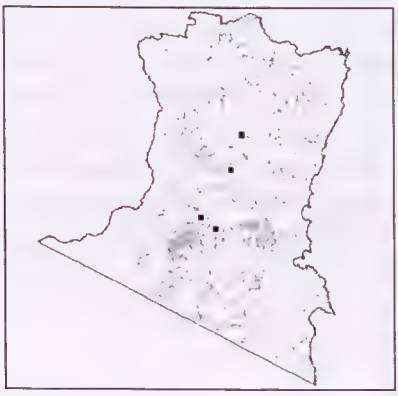
Map Unit 39: Northern Riparian Scrub

Northern Riparian Scrub has a patchy shrub stratum up to 4 m tall, dominated by *Acacia floribunda* and *Leptospermum emarginatum* with *Kunzea ericoides, Lomatia myricoides, Acacia mearnsii, Bursaria spinosa, Correa reflexa* and *Exocarpos cupressiformis.* Scattered emergent trees include *Eucalyptus elata* and other eucalypts up to 15 m tall from adjacent forest vegetation. The patchy groundcover is dominated by grasses and graminoids *Lomandra longifolia, Entolasia stricta, Themeda australis* and *Microlaena stipoides,* with small scattered herbs including *Dianella revoluta, Opercularia aspera* and *Persicaria decipiens.* Northern Riparian Scrub is restricted to riverine alluvium derived from granitoid substrates at elevations up to 250 m along major streams in the north, including the lower Bemboka River and lower reaches of Tantawangalo, Stockyard and Myanba Creeks. It occurs in lower rainfall districts (< 850 mm annual precipitation) than Southern Riparian Scrub (Map Unit 38) and has a different shrub composition. No similar assemblages have been described in adjacent regions (Austin 1978, Woodgate et al. 1994). Over one-third of Northern Riparian Scrub has been cleared in agricultural districts and almost all of the remainder is threatened by further clearing and degradation on private land. The principal threats associated with agricultural land uses include sedimentation, nutrification, weed invasion and physical damage by stock. Some sedimentation may originate from roadworks and logging in steeper, higher rainfall areas in the upper catchments. Frequent burning of adjacent vegetation may also threaten shrub diversity at some sites.

Species richness: 37 ± 7 (0.04 ha)
Extant area: 447 ha
Proportion cleared: 35%
Number of samples: 5

Table 39a. Diagnostic plant species of Map Unit 39.

Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Acacia floribunda	1	3(2–3)	0.014	2(1–3)	positive
Entolasia stricta	0.6	2(1–2)	0.18	1(1–2)	positive
Kunzea ericoides	0.6	2(2–3)	0.042	2(1–3)	positive
Leptospermum emarginatum	1	2(2–3)	0.003	3(2–3)	positive
Leptospermum polygalifolium subsp. *polygalifolium*	0.2	3(3–3)	0	0(0–0)	positive
Lomatia myricoides	0.6	2(2–2)	0.074	1(1–2)	positive
Themeda australis	0.6	2(1–2)	0.113	2(1–3)	positive
Lomandra longifolia	1	2(3–3)	0.547	2(1–2)	frequent
Acacia mearnsii	1	1(1–2)	0.16	2(1–3)	frequent
Bursaria spinosa	0.6	1(2–3)	0.121	1(1–2)	frequent
Correa reflexa	0.6	1(1–2)	0.125	1(1–2)	frequent
Dianella revoluta var. *revoluta*	0.6	1(1–1)	0.08	1(1–1)	frequent
Exocarpos cupressiformis	0.6	1(1–2)	0.047	1(1–2)	frequent
Microlaena stipoides var. *stipoides*	0.8	1(1–2)	0.352	2(1–2)	frequent
Opercularia aspera	0.6	1(1–2)	0.138	1(1–1)	frequent
Persicaria decipiens	0.6	1(1–1)	0.003	1(1–2)	frequent
Eucalyptus elata	0.4	1.5(1–2)	0.112	3(2–3)	uninformative
Eucalyptus maidenii	0.4	3(2–4)	0.062	3(2–3)	uninformative
Eucalyptus muelleriana	0.2	2(2–2)	0.142	3(2–4)	uninformative
Eucalyptus polyanthemos subsp. *vestita*	0.2	2(2–2)	0.012	2.5(2–3)	uninformative
Eucalyptus tereticornis	0.2	3(3–3)	0.046	3(1–3)	uninformative
Poa meionectes	0.2	2(2–2)	0.54	2(1–3)	negative
Pteridium esculentum	0.2	1(1–1)	0.578	2(1–3)	negative



Map 39. Distribution of samples of Northern Riparian Scrub (Map Unit 39) shown by large black squares. Samples of other map units shown as small grey points.

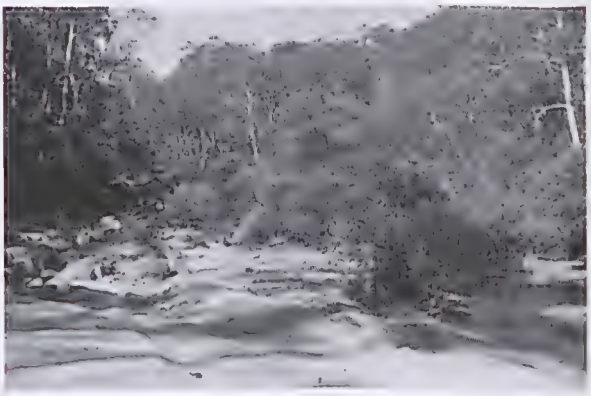


Plate 39. Northern Riparian Scrub (Map Unit 39) with *Acacia floribunda* and *Leptospermum emarginatum* in the sandy bed of Myrtle Creek, Yowaka section of South East Forests National Park.

Table 39b. Vegetation structure of Map Unit 39. Frequency is the proportion of samples in which strata were present. Height and cover data are means with standard errors in parentheses (n=5).

Stratum	Frequency (%)	Height (m)	Cover (%)
Tree	0	-(-)	-(-)
Small tree	60	13.0(3.1)	15(10)
Shrub	100	3.6(0.7)	43(11)
Ground cover	100	0.4(0.1)	19(9)

Table 39c. Habitat characteristics of Map Unit 39. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5° and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		803	796–815	5
Altitude (m)		171	95–250	5
Slope (degrees)		4	0–5	5
Terrain class				
North	20			1
Intermediate	0			0
South	20			1
Flat	60			3
Parent material				
Devonian granitoids	100			5

Map Unit 40: Riverine Forest

Riverine Forest is dominated by *Casuarina cunninghamiana* up to 30 m tall with a tall shrub stratum (c. 8 m) including *Acacia floribunda, A. mearnsii* and *Hymenanthera dentata.* The dense but patchy groundcover is dominated by grasses and graminoids including *Entolasia marginata, Microlaena stipoides, Oplismenus aemulus* and *Lomandra longifolia,* with herbs such as *Geranium solanderi* and *Sigesbeckia orientalis.* Riverine Forest is restricted to riverine alluvium derived from granitoid or sedimentary parent materials below 20 m elevation along the lower Brogo River on the Bega floodplain. More than one-fifth of its original extent has been lost to clearing, although this is a conservative estimate, as it may have extended up the Bega River prior to settlement. The remaining 200 ha occur on private land and are threatened by clearing and degradation associated with agricultural land uses including sedimentation, nutrification, weed invasion and physical damage by stock. Limited stands near Bega that are open to public access are also susceptible to trampling, rubbish dumping and uncontrolled fires. Related and similarly depleted assemblages may occur on floodplains further north (e.g. on the lower Tuross and Moruya Rivers), but none occur to the south, since *C. cunninghamiana* reaches its southern limit at Bega (Keith 1990).

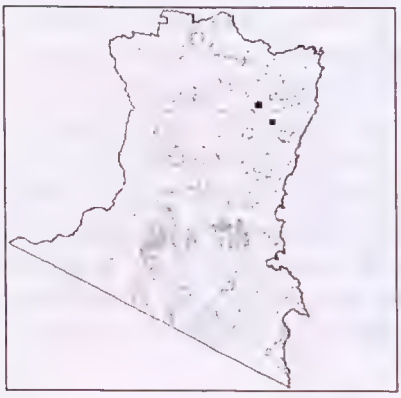
Species richness: 27 ± 9 (0.04 ha)
Extant area: 197 ha
Proportion cleared: 21% (probably an underestimate)
Number of samples: 4

Table 40a. Diagnostic plant species of Map Unit 40.

Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Acacia floribunda	1	2.5(1–3)	0.015	2(1–3)	positive
Acacia mearnsii	1	3(2–3)	0.161	2(1–3)	positive
Aneilema biflorum	0.25	1(1–1)	0	0(0–0)	positive
Casuarina cunninghamiana	1	4(3–4)	0	0(0–0)	positive
Cyperus imbecillis	0.25	1(1–1)	0	0(0–0)	positive
Microlaena stipoides var. *stipoides*	1	2.5(2–3)	0.352	1(1–2)	positive
Omalanthus stillingiifolius	0.25	1(1–1)	0	0(0–0)	positive
Entolasia marginata	1	1(1–1)	0.044	1(1–2)	frequent
Geranium solanderi	0.75	1(1–1)	0.091	1(1–2)	frequent
Hymenanthera dentata	1	1.5(1–3)	0.067	1(1–2)	frequent
Oplimensus aemulus var. *aemulus*	1	1.5(1–2)	0.007	2(1–2)	frequent
Sigesbeckia orientalis	0.75	1(1–1)	0.076	1(1–2)	frequent
Lomandra longifolia	1	1(1–2)	0.548	2(1–2)	frequent
Poa meionectes	0	0(1–0)	0.54	2(1–3)	negative
Pteridium esculentum	0.25	1(1–1)	0.578	2(1–3)	negative

Table 40b. Vegetation structure of Map Unit 40. Frequency is the proportion of samples in which strata were present. Height and cover data are means with standard errors in parentheses (n=4).

Stratum	Frequency (%)	Height (m)	Cover (%)
Tree	100	28.0(1.8)	26(6)
Small tree	100	8.0(1.4)	11(3)
Shrub	75	2.7(0.3)	21(10)
Ground cover	100	0.3(0.1)	52(20)



Map 40. Distribution of samples of Riverine Forest (Map Unit 40) shown by large black squares. Samples of other map units shown as small grey points.

Plate 40. Riverine Forest (Map Unit 40) dominated by *Casuarina cunninghamiana* with *Acacia mearnsii* and scattered *Lomandra longifolia* on the lower Brogo River downstream from Brogo Pass.

Table 40c. Habitat characteristics of Map Unit 40. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5° and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		875	862–887	4
Altitude (m)		26	15–36	4
Slope (degrees)		3	1–5	4
Terrain class				
North	0			0
Intermediate	25			1
South	25			1
Flat	50			2
Parent material				
Devonian granitoids	100			4

Map Unit 41: Mountain Intermediate Shrub Forest

Mountain Intermediate Shrub Forest is a tall forest dominated by *Eucalyptus fraxinoides* with *E. sieberi,* averaging 25 m in height. Its open shrub stratum includes *Leucopogon lanceolatus, Persoonia silvatica* and *Platysace lanceolata* with smaller shrubs including *Goodenia ovata* and *Hibbertia aspera.* The groundcover comprises scattered clumps of grasses, graminoids and lilioids *Hierochloe rariflora, Lomandra longifolia, Dianella tasmanica* and *Poa meionectes,* and bracken *Pteridium esculentum.* Mountain Intermediate Shrub Forest typically occupies steep, sheltered upper slopes either on metasediments or granitoid substrates. Usually it is found above 700 m elevation on the tableland range and outlying mountains (Burragate Peak, Mt Imlay and Letts Mountain), although unusual stands occur below 400 m on the Howe Range near the Victorian border. These latter stands extend across the border a short distance, but otherwise no similar assemblage has been described in East Gippsland (Woodgate et al. 1994). North from Brown Mountain, Mountain Intermediate Shrub Forest grades into Wadbilliga Range Shrub Forest (Map Unit W2). Mountain Intermediate Shrub Forest remains uncleared due to its occurrence in rugged inaccessible terrain. Due to its habitat and high level of representation in reserves, logging is unlikely to pose significant threats to this assemblage in future. Frequent high intensity fires are likely to be the principal conservation issues, since the dominant tree species are killed in such events and rely on seedling regeneration. Intervals between planned and unplanned fires need to be long enough to allow replenishment of seed banks and restoration of habitat structure if losses of diversity are to be avoided.

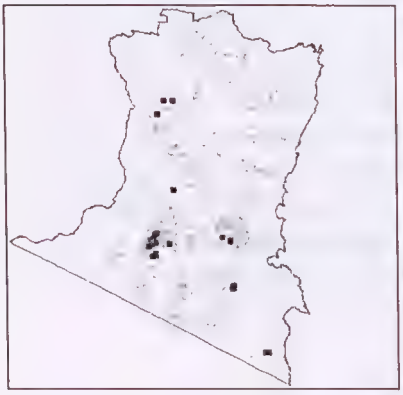
Species richness: 21 ± 1 (0.04 ha)
Extant area: 1877 ha
Proportion cleared: 0%
Number of samples: 28

Table 41a. Diagnostic plant species of Map Unit 41.

Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Eucalyptus fraxinoides	0.893	4(4–5)	0.012	3(2–4)	positive
Eucalyptus sieberi	0.536	2(1–3)	0.278	3(2–4)	positive
Gaultheria appressa	0.036	1(1–1)	0	0(0–0)	positive
Hierochloe rariflora	0.536	2(1–3)	0.175	2(1–3)	positive
Leucopogon lanceolatus var. *lanceolatus*	0.893	2(2–3)	0.396	1(1–2)	positive
Persoonia silvatica	0.5	2(1–2)	0.035	1(1–2)	positive
Lomandra longifolia	0.714	2(1–2)	0.546	2(1–2)	frequent
Pteridium esculentum	0.821	3(2–3)	0.572	2(1–3)	frequent
Dianella tasmanica	0.857	1(1–2)	0.223	1(1–2)	frequent
Platysace lanceolata	0.714	1(1–2)	0.242	2(1–2)	frequent
Poa meionectes	0.571	1(1–2)	0.538	2(1–3)	frequent
Angophora floribunda	0.036	3(3–3)	0.096	2(1–3)	uninformative
Eucalyptus agglomerata	0.036	3(3–3)	0.11	3(2–3)	uninformative
Eucalyptus cypellocarpa	0.107	1(1–1)	0.318	3(2–3)	uninformative
Eucalyptus fastigata	0.036	4(4–4)	0.143	3(3–4)	uninformative
Eucalyptus globoidea	0.036	2(2–2)	0.247	3(1–3)	uninformative
Eucalyptus obliqua	0.179	1(1–4)	0.19	3(2–4)	uninformative

Table 41b. Vegetation structure of Map Unit 41. Frequency is the proportion of samples in which strata were present. Height and cover data are means with standard errors in parentheses (n=22).

Stratum	Frequency (%)	Height (m)	Cover (%)
Tree	100	25.3(1.1)	42(3)
Small tree	22.7	8.4(1.9)	29(9)
Shrub	100	2.4(0.3)	24(4)
Ground cover	100	0.6(0.1)	23(3)



Map 41. Distribution of samples of Mountain Intermediate Shrub Forest (Map Unit 41) shown by large black squares. Samples of other map units shown as small grey points.

Plate 41. Mountain Intermediate Shrub Forest (Map Unit 41) dominated by *Eucalyptus fraxinoides* with a sparse cover of shrubs including *Persoonia silvatica* on the upper eastern face of Mt Imlay, Mt Imlay National Park.

Table 41c. Habitat characteristics of Map Unit 41. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5° and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		1116	1045–1199	28
Altitude (m)		854	740–1013	27
Slope (degrees)		20	10–29	27
Terrain class				
North	15			4
Intermediate	41			11
South	37			10
Flat	7			2
Parent material				
Devonian granitoids	68			19
Devonian high quartz sedimentaries	29			8
Ordovician high quartz sedimentaries	4			1

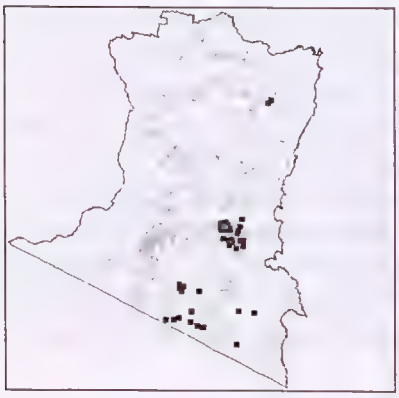
Map Unit 42: Inland Intermediate Shrub Forest

Inland Intermediate Shrub Forest is a tall forest (c. 30 m) dominated by *Eucalyptus obliqua* and *E. sieberi* sometimes with *E. cypellocarpa.* It has a relatively dense shrub stratum including *Acacia obtusifolia, Epacris impressa, Leucopogon lanceolatus, Pultenaea daphnoides* and *Persoonia linearis,* with smaller shrubs including *Goodenia ovata* and *Hibbertia aspera.* The tall semi-continuous groundcover comprises grasses and graminoids *Tetrarrhena juncea, Lomandra longifolia* and *Poa meionectes,* herbs *Gonocarpus teucrioides* and *Dianella caerulea,* and bracken *Pteridium esculentum.* Inland Intermediate Shrub Forest occurs on sheltered slopes either on metasediments or granitoid substrates at 150–650 m elevation in the coastal ranges and hinterland south from Merimbula. No similar assemblages are known to the north (Austin 1978, CSIRO 1996), while the most similar assemblage described in East Gippsland (Community 16.5, Forbes et al. 1982) shares few of the major understorey species and has relatively higher and lower frequencies of *E. globoidea* and *E. cypellocarpa*, respectively. Relatively little Inland Intermediate Shrub Forest has been cleared, most occurring on public land within production forest, while about one-quarter is reserved. The principal threat is frequent disturbance regimes that include logging (outside reserves) and fire in combination. These regimes reduce diversity by interrupting life-cycle processes of woody species (Keith 1996). Logging followed by regeneration burns and thinning may change the relative abundance of eucalypt species, particularly *E. sieberi* (Bridges 1983). Intervals between planned and unplanned disturbances need to be long enough to allow replenishment of seed banks and restoration of habitat structure if losses of diversity are to be avoided.

Species richness: 30 ± 1 (0.04 ha)
Extant area: 21 429 ha
Proportion cleared: 2%
Number of samples: 64

Table 42a. Diagnostic plant species of Map Unit 42.

Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Acacia aculeatissima	0.016	1(1–1)	0	0(0–0)	positive
Acacia obtusifolia	0.547	3(3–3)	0.068	3(2–3)	positive
Epacris impressa	0.641	2(1–2)	0.176	2(1–2)	positive
Eucalyptus obliqua	0.672	3(1–3)	0.168	3(2–4)	positive
Eucalyptus sieberi	0.797	3(3–4)	0.259	3(2–4)	positive
Gonocarpus teucrioides	0.875	3(2–3)	0.291	1(1–2)	positive
Lepidosperma elatius	0.016	1(1–1)	0	0(0–0)	positive
Leucopogon lanceolatus var. *lanceolatus*	0.813	2(1–2)	0.387	1(1–2)	positive
Pultenaea daphnoides	0.75	2(1–3)	0.067	1(1–2)	positive
Tetrarrhena juncea	0.672	2(2–3)	0.16	2(1–3)	positive
Lomandra longifolia	0.578	2(1–2)	0.548	2(1–2)	frequent
Poa meionectes	0.672	2(1–2)	0.533	2(1–3)	frequent
Pteridium esculentum	0.938	3(2–3)	0.56	2(1–3)	frequent
Billardiera scandens	0.828	1(1–1)	0.306	1(1–1)	frequent
Dianella caerulea	0.672	1(1–2)	0.261	1(1–2)	frequent
Persoonia linearis	0.844	1(1–2)	0.261	1(1–1)	frequent
Angophora floribunda	0.016	2(2–2)	0.099	2(1–3)	uninformative
Eucalyptus agglomerata	0.203	3(2–3)	0.104	3(2–3)	uninformative
Eucalyptus croajingolensis	0.016	2(2–2)	0.002	3(2–3)	uninformative
Eucalyptus cypellocarpa	0.438	3(1–3)	0.308	3(2–3)	uninformative
Eucalyptus elata	0.047	2(1–3)	0.116	3(2–3)	uninformative
Eucalyptus fastigata	0.031	3.5(3–4)	0.146	3(3–4)	uninformative
Eucalyptus globoidea	0.234	2(1–2)	0.243	3(1–3)	uninformative
Eucalyptus longifolia	0.016	3(3–3)	0.031	3(2–3)	uninformative
Eucalyptus muelleriana	0.234	3(3–3)	0.138	3(2–4)	uninformative
Eucalyptus radiata	0.094	2(1–2)	0.076	3(1–3)	uninformative
Eucalyptus smithii	0.031	2.5(1–4)	0.046	2(1–3)	uninformative
Eucalyptus sp. aff. *radiata*	0.047	4(3–4)	0.035	3(2–3)	uninformative



Map 42. Distribution of samples of Coastal Intermediate Shrub Forest (Map Unit 42) shown by large black squares. Samples of other map units shown as small grey points.

Plate 42. Coastal Intermediate Shrub Forest (Map Unit 42) dominated by *Eucalyptus obliqua* and *E. sieberi* with *Acacia terminalis, A. longifolia, Pultenaea daphnoides* and *Pteridium esculentum* on Poole Fire Trail near Mt Poole Flora Reserve in Yambulla State Forest.

Table 42b. Vegetation structure of Map Unit 42. Frequency is the proportion of samples in which strata were present. Height and cover data are means with standard errors in parentheses (n=16).

Stratum	Frequency (%)	Height (m)	Cover (%)
Tree	100	29.3(1.5)	37(2)
Small tree	12.5	12.0(3.0)	21(19)
Shrub	100	3.3(0.4)	39(4)
Ground cover	100	0.9(0.1)	56(7)

Table 42c. Habitat characteristics of Map Unit 42. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5° and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		993	952–1031	64
Altitude (m)		418	330–540	39
Slope (degrees)		13	7–17	32
Terrain class				
North	16			5
Intermediate	34			11
South	47			15
Flat	3			1
Parent material				
Devonian Basalt	2			1
Devonian granitoids	69			44
Devonian high quartz sedimentaries	11			7
Low quartz sedimentaries	13			8
Ordovician high quartz sedimentaries	6			4

Map Unit 43: Mountain Sandstone Shrub Forest

Mountain Sandstone Shrub Forest is dominated by *Eucalyptus cypellocarpa, E. globoidea* and *E. sieberi* up to 25 m tall. It may have two prominent sclerophyllous shrub strata 1–5 m tall including *Acacia falciformis, Daviesia ulicifolia, Epacris impressa, Exocarpos strictus, Leucopogon lanceolatus, Persoonia linearis, Platysace lanceolata* and *Olearia erubescens.* The open groundcover comprises grasses and graminoids *Lomandra longifolia* and *Poa meionectes,* herbs *Gonocarpus teucrioides, Dianella caerulea, Viola hederacea* and *Senecio* sp. E, and bracken *Pteridium esculentum.* Mountain Sandstone Shrub Forest occurs on ridges and upper slopes associated with Nungatta Mountain at 400–900 m elevation. Here, the substrate is Genoa Sandstone and underlying mudstones, although outlying stands occur on granitoid ridges on the escarpment range (Nalbaugh Plateau and Big Jack Mountain). This assemblage differs from Sandstone Dry Shrub Forest (Map Unit 25) in its lack of *E. obliqua* and *E.* sp. aff. *radiata* which are substituted by other tree species, its different shrub composition and its shorter and more open groundcover. Although Mountain Sandstone Shrub Forest does not readily match any assemblages described in East Gippsland (Forbes et al. 1982), similar assemblages might occur within the dry sclerophyll forest complex (Woodgate et al. 1994) on Genoa sandstones across the border in the Coopracambra area. A negligible proportion of this assemblage has been cleared and almost all is represented within national parks. The principal threat is frequent fire regimes that

may reduce diversity by interrupting life-cycle processes of woody species (Keith 1996). Intervals between planned and unplanned disturbances need to be long enough to allow replenishment of seed banks and restoration of habitat structure if losses of diversity are to be avoided.

Species richness: 34 ± 2 (0.04 ha)
Extant area: 2484 ha
Proportion cleared: 1%
Number of samples: 13

Table 43a. Diagnostic plant species of Map Unit 43.

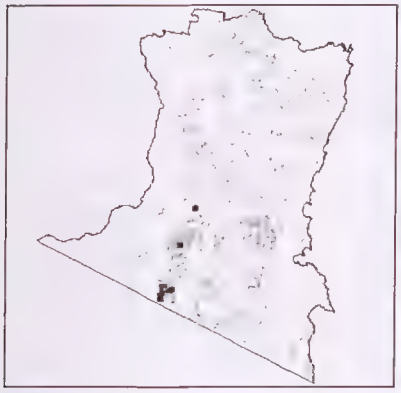
Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Acacia falciformis	0.846	3(2–4)	0.184	2(1–3)	positive
Asterolasia asteriscophora	0.077	3(3–3)	0	0(0–0)	positive
Daviesia ulicifolia	0.539	2(1–2)	0.055	1.5(1–2)	positive
Deyeuxia nudiflora	0.077	1(1–1)	0	0(0–0)	positive
Dianella caerulea	0.539	2(1–2)	0.276	1(1–2)	positive
Epacris impressa	0.769	2(1–2)	0.191	2(1–2)	positive
Eucalyptus cypellocarpa	0.923	3(1–3)	0.308	3(2–3)	positive
Eucalyptus globoidea	0.692	2(1–3)	0.239	3(1–3)	positive
Eucalyptus sieberi	0.692	3(3–4)	0.279	3(2–4)	positive
Exocarpos strictus	0.846	2(1–3)	0.165	1(1–2)	positive
Gonocarpus teucrioides	0.769	2(1–2)	0.312	2(1–2)	positive
Leucopogon lanceolatus var. *lanceolatus*	0.923	2(2–2)	0.401	1(1–2)	positive
Persoonia linearis	0.846	2(1–2)	0.281	1(1–1)	positive
Platysace lanceolata	1	3(2–4)	0.245	2(1–2)	positive
Viola hederacea subsp. *hederacea*	0.692	2(1–2)	0.435	2(1–2)	positive
Lomandra longifolia	0.846	2(1–2)	0.546	2(1–2)	frequent
Poa meionectes	0.769	2.5(2–3)	0.537	2(1–3)	frequent
Pteridium esculentum	0.692	2(2–3)	0.576	2(1–3)	frequent
Olearia erubescens	0.615	1(1–2)	0.062	1(1–1)	frequent
Senecio sp. E	0.692	1(1–2)	0.189	1(1–2)	frequent
Eucalyptus agglomerata	0.308	3(3–3)	0.107	3(2–3)	uninformative
Eucalyptus angophoroides	0.154	2.5(1–4)	0.043	2(1–3)	uninformative
Eucalyptus elata	0.154	2.5(2–3)	0.112	3(2–3)	uninformative
Eucalyptus mackintii	0.231	3(3–3)	0.002	4(3–4)	uninformative
Eucalyptus muelleriana	0.154	3(2–4)	0.142	3(2–4)	uninformative
Eucalyptus obliqua	0.077	4(4–4)	0.191	3(2–4)	uninformative
Eucalyptus sp. aff. *radiata*	0.077	2(2–2)	0.035	3(2–3)	uninformative

Table 43b. Vegetation structure of Map Unit 43. Frequency is the proportion of samples in which strata were present. Height and cover data are means with standard errors in parentheses (n=12).

Stratum	Frequency (%)	Height (m)	Cover (%)
Tree	100	23.8(1.9)	35(2)
Small tree	41.7	4.9(1.1)	37(3)
Shrub	100	1.3(0.2)	40(4)
Ground cover	100	0.5(0.1)	34(6)

Table 43c. Habitat characteristics of Map Unit 43. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5° and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		1065	1014–1131	13
Altitude (m)		632	490–740	13
Slope (degrees)		19	15–24	13
Terrain class				
North	8			1
Intermediate	62			8
South	23			3
Flat	8			1
Parent material				
Devonian granitoids	23			3
Devonian high quartz sedimentaries	77			10



Map 43. Distribution of samples of Mountain Sandstone Dry Shrub Forest (Map Unit 43) shown by large black squares. Samples of other map units shown as small grey points.

Plate 43. Mountain Sandstone Dry Shrub Forest (Map Unit 43) dominated by *Eucalyptus sieberi* and *E. cypellocarpa* with *Persoonia linearis, Podolobium ilicifolium, Epacris impressa* and *Acacia falciformis* on the western rim of Nungatta Plateau, Genoa section of South East Forests National Park.

Map Unit 44: Foothills Dry Shrub Forest

Foothills Dry Shrub Forest is dominated by *Eucalyptus sieberi* sometimes with *E. globoidea* up to 25 m tall. It has an open sclerophyllous shrub stratum including *Acacia falciformis, Leucopogon lanceolatus, Persoonia linearis* and *Platysace lanceolata.* The groundcover comprises scattered grasses and graminoids *Hierochloe rariflora, Tetrarrhena juncea, Lomandra longifolia* and *Poa meionectes,* herbs *Poranthera microphylla* and *Viola hederacea,* and bracken *Pteridium esculentum.* Foothills Dry Shrub Forest occurs on exposed ridges and slopes usually at 500–900 m elevation on granitoid substrates or more rarely on metasediments. Occurrences are scattered widely on the coastal and escarpment ranges. Similar assemblages occur both north (Austin 1978, CSIRO 1996) and south within the shrubby dry forest complex (Ecological Vegetation Class 21, Woodgate et al. 1994). Relatively little Foothills Dry Shrub Forest has been

cleared, most being reserved while about one-quarter occurs within production forest. The principal threat is frequent disturbance regimes that include logging (outside reserves) and fire in combination. These regimes reduce diversity by interrupting life-cycle processes of woody species (Keith 1996). Logging followed by regeneration burns and thinning may change the relative abundance of eucalypt species, particularly *E. sieberi* (Bridges 1983). Intervals between planned and unplanned disturbances need to be long enough to allow replenishment of seed banks and restoration of habitat structure if losses of diversity are to be avoided.

Species richness: 30 ± 1 (0.04 ha)
Extant area: 3152 ha
Proportion cleared: 6%
Number of samples: 29

Table 44a. Diagnostic plant species of Map Unit 44.

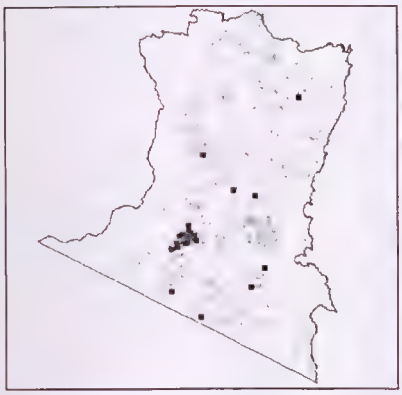
Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Acacia falciformis	0.759	2(2–3)	0.178	2(1–3)	positive
Actinotus minor	0.034	1(1–1)	0	0(0–0)	positive
Eucalyptus sieberi	1	4(3–4)	0.268	3(2–4)	positive
Hierochloe rariflora	0.724	2(2–4)	0.171	2(1–3)	positive
Leucopogon lanceolatus var. *lanceolatus*	0.897	2(1–2)	0.396	1(1–2)	positive
Tetrarrhena juncea	0.517	2(1–2)	0.175	2(1–3)	positive
Lomandra longifolia	1	2(1–2)	0.54	2(1–2)	frequent
Poa meionectes	0.724	2(1–3)	0.535	2(1–3)	frequent
Pteridium esculentum	1	3(2–3)	0.568	2(1–3)	frequent
Persoonia linearis	0.828	1(1–2)	0.275	1(1–2)	frequent
Platysace lanceolata	0.655	1(1–2)	0.243	2(1–2)	frequent
Poranthera microphylla	0.69	1(1–2)	0.214	1(1–1)	frequent
Viola hederacea subsp. *hederacea*	0.621	1(1–2)	0.434	2(1–2)	frequent
Eucalyptus agglomerata	0.069	2.5(2–3)	0.11	3(2–3)	uninformative
Eucalyptus cypellocarpa	0.241	1(1–3)	0.315	3(2–3)	uninformative
Eucalyptus elata	0.103	1(1–4)	0.113	3(2–3)	uninformative
Eucalyptus fastigata	0.034	1(1–1)	0.143	3(3–4)	uninformative
Eucalyptus globoidea	0.414	1.5(1–4)	0.239	3(1–3)	uninformative
Eucalyptus muelleriana	0.034	3(3–3)	0.144	3(2–4)	uninformative
Eucalyptus obliqua	0.276	3(2–4)	0.188	3(2–4)	uninformative
Eucalyptus radiata	0.034	1(1–1)	0.078	3(1–3)	uninformative
Eucalyptus smithii	0.034	2(2–2)	0.046	2(1–3)	uninformative
Eucalyptus sp. aff. *radiata*	0.138	3(2–3)	0.033	3(2–3)	uninformative

Table 44b. Vegetation structure of Map Unit 44. Frequency is the proportion of samples in which strata were present. Height and cover data are means with standard errors in parentheses (n=21).

Stratum	Frequency (%)	Height (m)	Cover (%)
Tree	100	24.5(1.0)	41(2)
Small tree	9.5	10.0(0.0)	15(10)
Shrub	100	2.7(0.2)	24(4)
Ground cover	100	0.7(0.1)	28(5)

Table 44c. Habitat characteristics of Map Unit 44. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5° and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		1033	992–1080	29
Altitude (m)		700	600–850	29
Slope (degrees)		13	3–22	28
Terrain class				
North	41			11
Intermediate	22			6
South	4			1
Flat	33			9
Parent material				
Devonian granitoids	83			24
Devonian high quartz sedimentaries	10			3
Ordovician high quartz sedimentaries	7			2



Map 44. Distribution of samples of Foothills Dry Shrub Forest (Map Unit 44) shown by large black squares. Samples of other map units shown as small grey points.

Plate 44. Foothills Dry Shrub Forest (Map Unit 44) dominated by *Eucalyptus sieberi* with occasional *E. cypellocarpa* and *Acacia falciformis, Leucopogon lanceolatus* and *Poa meionectes* near Mt Calabash, Coolangubra State Forest.

Map Unit 45: Mountain Dry Shrub Forest

Mountain Dry Shrub Forest is dominated by *Eucalyptus sieberi* usually in pure stands c. 20 m tall. It has a prominent sclerophyllous shrub stratum including *Acacia terminalis, Leucopogon lanceolatus, Lomatia ilicifolia, Monotoca scoparia, Platysace lanceolata* and *Persoonia linearis.* The sparse groundcover includes *Lomandra longifolia* and *Pteridium esculentum.* Mountain Dry Shrub Forest occurs on exposed stony ridges and upper slopes at 600–1000 m elevation on granitoid substrates or more rarely on metasediments on the escarpment range and hinterland mountains. It differs from Foothills Dry Shrub Forest (Map Unit 44) in the composition of its shrub stratum, the low frequency of co-dominant tree species and its less developed ground stratum. Similar assemblages occur both north (Austin 1978, CSIRO 1996) and south within the

shrubby dry forest complex (Ecological Vegetation Class 21, Woodgate et al. 1994). A negligible area of Mountain Dry Shrub Forest has been cleared, over half being reserved while the remainder occurs within production forest on private and public land. The principal threat is frequent disturbance regimes that include logging (outside reserves) and fire in combination. These regimes reduce diversity by interrupting life-cycle processes of woody species (Keith 1996). Logging followed by regeneration burns and thinning may change the relative abundance of eucalypt species, particularly *E. sieberi* (Bridges 1983). Intervals between planned and unplanned disturbances need to be long enough to allow replenishment of seed banks and restoration of habitat structure if losses of diversity are to be avoided.

Species richness: 29 ± 3 (0.04 ha)
Extant area: 1930 ha
Proportion cleared: 5%
Number of samples: 23

Table 45a. Diagnostic plant species of Map Unit 45.

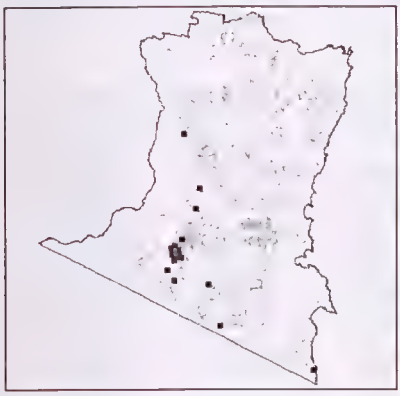
Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Acacia terminalis	0.826	3(1–3)	0.108	2(1–3)	positive
Eucalyptus sieberi	1	4(4–4)	0.271	3(2–4)	positive
Leucopogon lanceolatus var. *lanceolatus*	0.739	2(1–3)	0.4	1(1–2)	positive
Lomatia ilicifolia	0.913	2(1–2)	0.119	1(1–2)	positive
Monotoca scoparia	0.87	2(1–3)	0.114	2(1–2)	positive
Platysace lanceolata	0.696	2(1–2)	0.244	2(1–2)	positive
Spyridium parvifolium	0.043	2(2–2)	0	0(0–0)	positive
Lomandra longifolia	1	2(2–3)	0.542	2(1–2)	frequent
Pteridium esculentum	0.913	3(2–3)	0.571	2(1–3)	frequent
Persoonia linearis	0.696	1(1–2)	0.28	1(1–2)	frequent
Eucalyptus consideniana	0.043	3(3–3)	0.021	2(1–3)	uninformative
Eucalyptus cypellocarpa	0.13	1(1–3)	0.317	3(2–3)	uninformative
Eucalyptus fraxinoides	0.13	3(1–4)	0.027	4(3–4)	uninformative
Eucalyptus globoidea	0.217	2(1–5)	0.243	3(1–3)	uninformative
Eucalyptus obliqua	0.261	2(1–3)	0.188	3(2–4)	uninformative
Eucalyptus radiata	0.043	1(1–1)	0.077	3(1–3)	uninformative
Eucalyptus sp. aff. *radiata*	0.174	1(1–3)	0.033	3(2–3)	uninformative
Poa meionectes	0.478	2(1–2)	0.54	2(1–3)	negative

Table 45b. Vegetation structure of Map Unit 45. Frequency is the proportion of samples in which strata were present. Height and cover data are means with standard errors in parentheses (n=15).

Stratum	Frequency (%)	Height (m)	Cover (%)
Tree	100	21.4(2.0)	38(3)
Small tree	20	6.0(1.5)	18(11)
Shrub	100	1.6(0.2)	34(3)
Ground cover	100	0.5(0.1)	21(5)

Table 45c. Habitat characteristics of Map Unit 45. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≥ 5°); north (slope > 5° and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		1047	986–1104	23
Altitude (m)		737	608–950	2
Slope (degrees)		11	3–18	23
Terrain class				
North	30			7
Intermediate	35			8
South	4			1
Flat	30			7
Parent material				
Devonian granitoids	87			20
Low quartz sedimentaries	4			1
Ordovician high quartz sedimentaries	4			1
Tertiary Alluvium	4			1



Map 45. Distribution of samples of Mountain Dry Shrub Forest (Map Unit 45) shown by large black squares. Samples of other map units shown as small grey points.

Plate 45. Mountain Dry Shrub Forest (Map Unit 45) dominated by *Eucalyptus sieberi* with *Lomatia ilicifolia, Hibbertia hermanniifolia, Lomandra longifolia* amd *Poa meionectes* near Mt Cathcart, Cathcart State Forest.

Map Unit 46A: Timbillica Dry Shrub Forest

Timbillica Dry Shrub Forest is c. 25 m tall dominated by *Eucalyptus consideniana, E. sieberi* and *E. agglomerata,* sometimes with *E. globoidea* and an open small tree stratum of *Allocasuarina littoralis* c. 8 m tall. Its prominent sclerophyllous shrub stratum includes *Acacia terminalis, Epacris impressa, Hibbertia empetrifolia, Monotoca scoparia, Tetratheca pilosa, Platysace lanceolata* and *Persoonia linearis.* The groundcover is dominated by grasses and graminoids *Caustis flexuosa, Gahnia radula, Tetrarrhena juncea, Lomandra longifolia, Poa meionectes* and *Lepidosperma laterale,* herbs *Gonocarpus teucrioides* and *Patersonia glabrata,* and bracken *Pteridium esculentum.* Vines of *Billardiera scandens* twine among the shrubs and groundcover. Timbillica Dry Shrub Forest occupies low ridges and slopes in undulating granitoid terrain at 50–300 m elevation

in the middle to lower reaches of the Wallagaraugh River catchment. A similar assemblage occurs east of Cann River in the lowlands of East Gippsland (Community 16.2, Forbes et al. 1982), although *E. consideniana* is less frequent and some differences in understorey composition (e.g. more abundant Proteaceae) are apparent. Negligible amounts of Timbillica Dry Shrub Forest have been cleared, and although numerous small patches are reserved mainly along the corridor within Wallagaraugh River Flora Reserve, most occurs within production forest. The principal threat is frequent disturbance regimes that include logging (outside reserves) and fire in combination. These regimes reduce diversity by interrupting life-cycle processes of woody species (Keith 1996). Logging followed by regeneration burns and thinning may change the relative abundance of eucalypt species, particularly *E. sieberi* (Bridges 1983). Intervals between planned and unplanned disturbances need to be long enough to allow replenishment of seed banks and restoration of habitat structure if losses of diversity are to be avoided.

Species richness: 36 ± 0 (0.04 ha)
Extant area: 22 797 ha
Proportion cleared: 1%
Number of samples: 24

Table 46Aa. Diagnostic plant species of Map Unit 46A.

Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Acacia lanigera	0.083	2.5(2–3)	0	0(0–0)	positive
Acacia terminalis	0.583	2(1–2)	0.112	2(1–3)	positive
Allocasuarina littoralis	0.542	3(1–3)	0.158	2(1–3)	positive
Caustis flexuosa	0.667	2(1–2)	0.028	2(1–3)	positive
Epacris impressa	0.833	2(1–2)	0.186	2(1–2)	positive
Eucalyptus agglomerata	0.583	3(3–3)	0.101	3(2–3)	positive
Eucalyptus consideniana	0.833	3(1–3)	0.008	2(1–3)	positive
Eucalyptus sieberi	0.667	2.5(1–3)	0.276	3(2–4)	positive
Gahnia radula	0.625	2(2–3)	0.082	2(1–3)	positive
Gonocarpus teucrioides	0.958	2(2–2)	0.305	2(1–2)	positive
Hibbertia empetrifolia	0.583	2(1–2)	0.057	1(1–2)	positive
Lasiopetalum ferrugineum var. *cordatum*	0.083	1.5(1–2)	0	0(0–0)	positive
Monotoca scoparia	0.833	2(1–3)	0.114	2(1–2)	positive
Platysace lanceolata	0.542	2(2–2)	0.247	2(1–2)	positive
Pomaderris andromedifolia	0.083	1.5(1–2)	0	0(0–0)	positive
Pomaderris discolor	0.042	1(1–1)	0	0(0–0)	positive
Tetrarrhena juncea	0.5	2(1–2)	0.177	2(1–3)	positive
Tetratheca pilosa subsp. *latifolia*	0.625	2(1–2)	0.017	1(1–2)	positive
Poa meionectes	0.792	2(1–2)	0.535	2(1–3)	frequent
Pteridium esculentum	0.958	2(2–3)	0.57	2(1–3)	frequent
Billardiera scandens	0.625	1(1–1)	0.324	1(1–1)	frequent
Lepidosperma laterale	0.917	1.5(1–2)	0.335	1(1–2)	frequent
Patersonia glabrata	0.917	1.5(1–2)	0.053	1(1–2)	frequent
Persoonia linearis	0.917	1(1–1)	0.276	1(1–2)	frequent
Callitris rhomboidea	0.042	1(1–1)	0.003	1(1–2)	uninformative
Eucalyptus angophoroides	0.167	2(1–3)	0.042	2(1–3)	uninformative
Eucalyptus cypellocarpa	0.042	1(1–1)	0.318	3(2–3)	uninformative
Eucalyptus globoidea	0.458	2(1–3)	0.239	3(1–3)	uninformative

Eucalyptus muelleriana	0.042	3(3–3)	0.144	3(2–4)	uninformative
Eucalyptus obliqua	0.083	1(1–1)	0.191	3(2–4)	uninformative
Eucalyptus radiata	0.083	3(3–3)	0.077	3(1–3)	uninformative
Eucalyptus sp. aff. *radiata*	0.042	3(3–3)	0.035	3(2–3)	uninformative
Eucalyptus viminalis	0.042	1(1–1)	0.057	3(1–3)	uninformative
Lomandra longifolia	0.208	2(1–2)	0.555	2(1–2)	negative

Table 46Ab. Vegetation structure of Map Unit 46A. Frequency is the proportion of samples in which strata were present. Height and cover data are means with standard errors in parentheses (n=19).

Stratum	Frequency (%)	Height (m)	Cover (%)
Tree	100	26.6(1.5)	24(1)
Small tree	52.6	8.1(1.1)	18(4)
Shrub	100	1.9(0.3)	21(3)
Ground cover	100	0.6(0.0)	13(2)

Table 46Ac. Habitat characteristics of Map Unit 46A. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5° and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

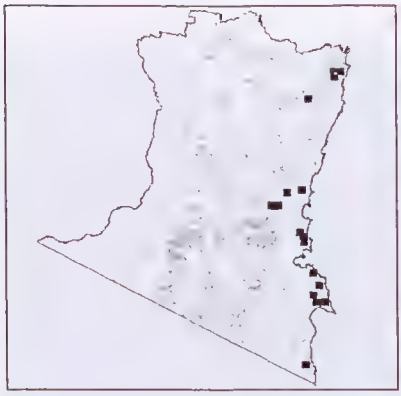
	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		926	886–966	24
Altitude (m)		264	185–338	19
Slope (degrees)		6	3–10	19
Terrain class				
North	26			5
Intermediate	26			5
South	11			2
Flat	37			7
Parent material				
Devonian granitoids	100			24

Map 46A. Distribution of samples of Timbillica Dry Shrub Forest (Map Unit 46A) shown by large black squares. Samples of other map units shown as small grey points.

Plate 46A. Timbillica Dry Shrub Forest (Map Unit 46A) dominated by *Eucalyptus consideniana* with *Allocasuarina littoralis, Hakea decurrens* ssp. *physocarpa, Daviesia buxifolia, Leptospermum trinervium* and *Acacia terminalis* on Imlay Road near Imlay Creek crossing, Yambulla State Forest.

Map Unit 46B: Lowland Dry Shrub Forest

Lowland Dry Shrub Forest is dominated by *Corymbia gummifera, Eucalyptus sieberi* and *E. globoidea* over 20 m tall, sometimes with *Angophora floribunda* and an open small tree stratum of *Allocasuarina littoralis* 8m tall. It has a diverse sclerophyllous shrub stratum including *Acacia terminalis, Bossiaea obcordata, Gompholobium glabratum, Leptospermum trinervium, Pimelea linifolia, Platysace lanceolata, Correa reflexa, Persoonia linearis* and several less frequent species including *Banksia spinulosa* and *Platylobium formosum.* The groundcover comprises scattered grasses *Chionochloa pallida* and *Entolasia stricta* (and *Anisopogon avenaceus* at lower frequency), herbs *Gonocarpus teucrioides, Patersonia glabrata* and *Xanthosia pilosa,* and bracken *Pteridium esculentum.* Lowland Dry Shrub Forest occurs on low ridges and moderate dry slopes in the coastal foothills and plains usually below 150 m elevation on metasediments or Tertiary alluvium. Some of these latter sites with deep sandy soils support relatively tall forest dominated by *E. pilularis.* A similar assemblage extends further north along the coastal strip at least as far as Bodalla (Austin 1978). The most similar assemblage in East Gippsland (Community 15.1, Forbes et al. 1982) has more restricted occurrences of *C. gummifera* and some differences in understorey composition (e.g. lower frequencies of *Bossiaea obcordata* and *Chionochloa pallida,* higher frequency of *Banksia serrata*). Significant occurrences of Lowland Dry Shrub Forest remain on all tenures, relatively little having been cleared. Although a few stands are threatened by coastal development and overuse, the principal threat is frequent disturbance regimes that include logging (outside reserves) and fire in combination. These regimes reduce diversity by interrupting life-cycle processes of woody species (Keith 1996). Logging followed by regeneration burns and thinning may change the relative abundance of eucalypt species, particularly *E. sieberi* (Bridges 1983). Intervals between planned and unplanned disturbances need to be long enough to allow replenishment of seed banks and restoration of habitat structure if losses of diversity are to be avoided.



Map 46B. Distribution of samples of Mountain Intermediate Shrub Forest (Map Unit 46B) shown by large black squares. Samples of other map units shown as small grey points.

Plate 46Ba. Lowland Dry Shrub Forest (Map Unit 46B) dominated by *Corymbia gummifera* and *E. sieberi* with *Banksia spinulosa, B. serrata, Pimelea linifolia* and *Acacia obtusifolia* north of Bellbird Creek in northern section of Ben Boyd National Park.

Plate 46Bb. Lowland Dry Shrub Forest (Map Unit 46B) variant dominated by *Eucalyptus pilularis* and *Corymbia gummifera* with tall *Banksia serrata, Acacia obtusifolia* and *Pteridium esculentum* north of Bellbird Creek in northern section of Ben Boyd National Park.

Species richness: 35 ± 2 (0.04 ha)
Extant area: 15 428 ha
Proportion cleared: 6%
Number of samples: 19

Table 46Ba. Diagnostic plant species of Map Unit 46B.

Species frequency	Target C/A	Target frequency	Residual C/A	Residual class	Fidelity
Acacia terminalis	0.842	2(1–3)	0.11	2(1–3)	positive
Allocasuarina littoralis	0.579	2(2–4)	0.159	2(1–3)	positive
Bossiaea obcordata	0.526	2(2–2)	0.021	2(2–3)	positive
Chionochloa pallida	0.579	3(3–4)	0.098	2(1–3)	positive
Corymbia gummifera	0.632	3(3–4)	0.012	3(2–3)	positive
Entolasia stricta	0.526	2(1–2)	0.177	1(1–2)	positive
Eucalyptus globoidea	0.526	2.5(1–3)	0.239	3(1–3)	positive
Eucalyptus sieberi	0.79	3(2–4)	0.276	3(2–4)	positive
Gompholobium glabratum	0.105	1.5(1–2)	0	0(0–0)	positive
Gonocarpus teucrioides	0.842	2(2–2)	0.309	2(1–2)	positive
Grevillea baueri	0.053	2(2–2)	0	0(0–0)	positive
Leptospermum trinervium	0.526	2(1–2)	0.023	2(1–3)	positive
Patersonia glabrata	0.737	2(2–2)	0.059	1(1–2)	positive
Pimelea linifolia subsp. *linifolia*	0.632	2(1–2)	0.03	1(1–2)	positive
Platysace lanceolata	0.737	2(2–2)	0.245	2(1–2)	positive
Xanthosia pilosa	0.579	2(1–2)	0.052	1(1–2)	positive
Pteridium esculentum	0.842	3(1–4)	0.573	2(1–3)	frequent
Correa reflexa	0.737	1(1–2)	0.119	1(1–2)	frequent
Persoonia linearis	0.895	1(1–2)	0.278	1(1–1)	frequent
Angophora floribunda	0.316	1.5(1–2)	0.092	2(1–3)	uninformative
Eucalyptus agglomerata	0.158	3(1–3)	0.108	3(2–3)	uninformative
Eucalyptus consideniana	0.105	2.5(2–3)	0.02	2(1–3)	uninformative
Eucalyptus muelleriana	0.053	2(2–2)	0.143	3(2–4)	uninformative
Eucalyptus pilularis	0.105	4(4–4)	0.002	1(1–3)	uninformative
Lomandra longifolia	0.316	1(1–3)	0.552	2(1–2)	negative
Poa meionectes	0.211	2(1–3)	0.543	2(1–3)	negative

Table 46Bb. Vegetation structure of Map Unit 46B. Frequency is the proportion of samples in which strata were present. Height and cover data are means with standard errors in parentheses (n=15).

Stratum	Frequency (%)	Height (m)	Cover (%)
Tree	100	22.1(1.3)	30(3)
Small tree	66.7	8.3(0.8)	21(4)
Shrub	100	1.7(0.3)	30(4)
Ground cover	100	0.5(0.0)	40(4)

Table 46Bc. Habitat characteristics of Map Unit 46B. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5° and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		887	860–915	19
Altitude (m)		104	65–135	19
Slope (degrees)		8	4–12	19
Terrain class				
North	5			1
Intermediate	42			8
South	16			3
Flat	37			7
Parent material				
Devonian granitoids	5			1
Devonian high quartz sedimentaries	58			11
Ordovician high quartz sedimentaries	16			3
Tertiary Alluvium	21			4

Map Unit 47: Eden Dry Shrub Forest

Eden Dry Shrub Forest is dominated by *Eucalyptus sieberi* and *Angophora floribunda* c. 20 m tall, with an open stratum of small trees, *Allocasuarina littoralis* c. 6 m tall. It has an open sclerophyllous shrub stratum including *Acacia terminalis, Epacris impressa, Pultenaea daphnoides, Leucopogon lanceolatus, Persoonia linearis* and *Platysace lanceolata.* The groundcover comprises grasses and graminoids *Gahnia radula* and *Tetrarrhena juncea,* herbs *Gonocarpus teucrioides, Xanthosia pilosa* and *Dianella caerulea,* and bracken *Pteridium esculentum.* Eden Dry Shrub Forest occupies coastal mountain ridges and coastal plateaux up to 800 m elevation on metasediments from the Nadgee coast to Mt Imlay. Although no similar assemblages have been explicitly described outside the Eden region (Austin 1978, Forbes et al. 1982), one may exist within the lowland sclerophyll forest complex in East Gippsland (Ecological Vegetation Class 16, Woodgate et al. 1994). Relatively little Eden Dry Shrub Forest has been cleared, most being reserved while about one-quarter occurs within public and private production forest. The principal threat is frequent disturbance regimes that include logging (outside reserves) and fire in combination. These regimes reduce diversity by interrupting life-cycle processes of woody species (Keith 1996). Logging followed by regeneration burns and thinning may change the relative abundance of eucalypt species, particularly *E. sieberi* (Bridges 1983). Intervals between planned and unplanned disturbances need to be long enough to allow replenishment of seed banks and restoration of habitat structure if losses of diversity are to be avoided. Two intense

fires occurred within 8 years over a large portion of the range of Eden Dry Shrub Forest in the 1970's. A long fire-free interval may therefore be necessary to ensure population recovery of some species and restoration of vegetation structure.

Species richness: 26 ± 1 (0.04 ha)
Extant area: 17 246 ha
Proportion cleared: 4%
Number of samples: 19

Table 47a. Diagnostic plant species of Map Unit 47.

Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Acacia terminalis	0.79	3(2–4)	0.111	2(1–3)	positive
Allocasuarina littoralis	0.684	2(1–4)	0.158	2(1–3)	positive
Angophora floribunda	0.526	3(2–3)	0.089	2(1–3)	positive
Epacris impressa	0.79	2(2–3)	0.189	2(1–2)	positive
Eucalyptus sieberi	0.895	3(3–4)	0.275	3(2–4)	positive
Gahnia radula	0.737	2(2–3)	0.083	2(1–3)	positive
Gonocarpus teucrioides	0.79	2(2–3)	0.31	2(1–2)	positive
Hibbertia saligna	0.053	2(2–2)	0	0(0–0)	positive
Pultenaea daphnoides	0.526	2(1–2)	0.091	1(1–2)	positive
Tetrarrhena juncea	0.737	3(2–3)	0.175	2(1–3)	positive
Xanthosia pilosa	0.79	2(1–2)	0.05	1(1–2)	positive
Pteridium esculentum	0.947	3(2–3)	0.572	2(1–3)	frequent
Dianella caerulea	0.632	1(1–2)	0.274	1(1–2)	frequent
Leucopogon lanceolatus var. *lanceolatus*	0.684	1(1–2)	0.402	1(1–2)	frequent
Persoonia linearis	0.684	1(1–2)	0.281	1(1–2)	frequent
Platysace lanceolata	0.947	1.5(1–2)	0.242	2(1–2)	frequent
Acacia subporosa	0.053	1(1–1)	0.004	2(1–2)	uninformative
Eucalyptus agglomerata	0.158	1(1–3)	0.108	3(2–3)	uninformative
Eucalyptus baxteri	0.053	3(3–3)	0.008	3(2–3)	uninformative
Eucalyptus elata	0.053	1(1–1)	0.114	3(2–3)	uninformative
Eucalyptus globoidea	0.105	2.5(2–3)	0.244	3(1–3)	uninformative
Eucalyptus longifolia	0.053	3(3–3)	0.03	3(2–3)	uninformative
Eucalyptus muelleriana	0.053	3(3–3)	0.143	3(2–4)	uninformative
Eucalyptus obliqua	0.105	1.5(1–2)	0.191	3(2–4)	uninformative
Eucalyptus smithii	0.053	3(3–3)	0.045	2(1–3)	uninformative
Lomandra longifolia	0.474	2(1–3)	0.55	2(1–2)	negative
Poa meionectes	0.158	1(1–2)	0.544	2(1–3)	negative

Table 47b. Vegetation structure of Map Unit 47. Frequency is the proportion of samples in which strata were present. Height and cover data are means with standard errors in parentheses (n=19).

Stratum	Frequency (%)	Height (m)	Cover (%)
Tree	100	20.2(1.5)	21(3)
Small tree	47.4	5.6(0.9)	30(9)
Shrub	100	2.5(0.3)	40(4)
Ground cover	100	0.8(0.1)	42(6)

Map 47. Distribution of samples of Eden Dry Shrub Forest (Map Unit 47) shown by large black squares. Samples of other map units shown as small grey points.

Plate 47. Eden Dry Shrub Forest (Map Unit 47) dominated by *Angophora floribunda* and *E. sieberi* with *Allocasuarina littoralis* and *Acacia falciformis* in the upper Merrica River catchment, Nadgee Nature Reserve.

Table 47c. Habitat characteristics of Map Unit 47. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5° and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		1031	949–1089	19
Altitude (m)		372	195–525	19
Slope (degrees)		13	6–21	19
Terrain class				
North	21			4
Intermediate	37			7
South	26			5
Flat	16			3
Parent material				
Devonian high quartz sedimentaries	95			18
Tertiary Alluvium	5			1

Map Unit 48: Mumbulla Dry Shrub Forest

Mumbulla Dry Shrub Forest is dominated by *Eucalyptus sieberi*, occasionally with *E. agglomerata* c. 20 m tall. Often there is an open stratum of small trees, *Allocasuarina littoralis* 6 m tall. It has a sparse sclerophyllous shrub stratum with *Bossiaea obcordata, Persoonia linearis, Platysace lanceolata* and *Correa reflexa*. The open groundcover comprises grasses and graminoids *Chionochloa pallida, Entolasia stricta, Lepidosperma urophorum, Lomandra confertifolia* ssp. *rubiginosa* and *L. multiflora*. Mumbulla Dry Shrub Forest occupies coastal mountain ridges at 150–650 m elevation on the Bega tonalite on Mumbulla and Dr George Mountains. Outlying stands may occur at Mt Imlay and the upper Wog Wog Creek area. No similar assemblages have been described in East Gippsland (Forbes et al. 1982). It seems unlikely that similar assemblages occur north of the study area due to the lack of tonalite coastal mountain habitat. A negligible area

of Mumbulla Dry Shrub Forest has been cleared, most being reserved while about one-sixth occurs within production forest. The principal threat is frequent disturbance regimes that include logging (outside reserves) and fire in combination. These regimes reduce diversity by interrupting life-cycle processes of woody species (Keith 1996). Logging followed by regeneration burns and thinning may change the relative abundance of eucalypt species, particularly *E. sieberi* (Bridges 1983). Intervals between planned and unplanned disturbances need to be long enough to allow replenishment of seed banks and restoration of habitat structure if losses of diversity are to be avoided.

Species richness: 28 ± 2 (0.04 ha)
Extant area: 4576 ha
Proportion cleared: 1%
Number of samples: 19

Table 48a. Diagnostic plant species of Map Unit 48.

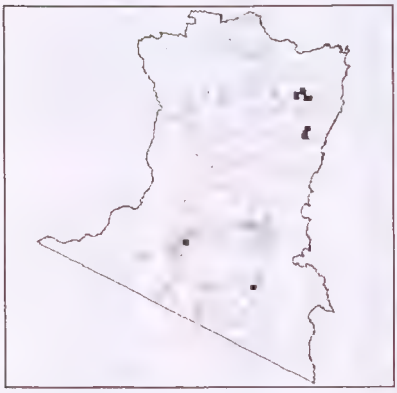
Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Allocasuarina littoralis	0.842	2(1–4)	0.156	2(1–3)	positive
Bossiaea obcordata	0.579	2(2–3)	0.021	2(2–2)	positive
Chionochloa pallida	0.632	3(3–4)	0.098	2(1–3)	positive
Cryptostylis erecta	0.053	1(1–1)	0	0(0–0)	positive
Entolasia stricta	0.526	2(1–2)	0.177	1(1–2)	positive
Eucalyptus sieberi	0.895	3(3–3)	0.275	3(2–4)	positive
Helichrysum collinum	0.053	2(2–2)	0	0(0–0)	positive
Lepidosperma urophorum	0.842	2(2–3)	0.061	1(1–2)	positive
Lomandra confertifolia subsp. *rubiginosa*	0.579	2(1–2)	0.03	1(1–2)	positive
Myoporum bateae	0.053	1(1–1)	0	0(0–0)	positive
Persoonia linearis	0.947	2(1–2)	0.277	1(1–1)	positive
Platysace lanceolata	0.947	2(2–2)	0.242	2(1–2)	positive
Senna odorata	0.053	1(1–1)	0	0(0–0)	positive
Solanum cinereum	0.053	1(1–1)	0	0(0–0)	positive
Correa reflexa	0.737	1(1–2)	0.119	1(1–2)	frequent
Lomandra multiflora	0.632	1(1–1)	0.246	1(1–2)	frequent
Angophora floribunda	0.158	3(1–3)	0.094	2(1–3)	uninformative
Eucalyptus agglomerata	0.368	3(2–3)	0.105	3(2–3)	uninformative
Eucalyptus elata	0.053	1(1–1)	0.114	3(2–3)	uninformative
Eucalyptus globoidea	0.211	3(3–3)	0.243	3(1–3)	uninformative
Eucalyptus smithii	0.053	4(4–4)	0.045	2(1–3)	uninformative
Lomandra longifolia	0.158	1(1–1)	0.554	2(1–2)	negative
Poa meionectes	0.211	1(1–2)	0.543	2(1–3)	negative
Pteridium esculentum	0.421	2(1–2)	0.579	2(1–3)	negative

Table 48b. Vegetation structure of Map Unit 48. Frequency is the proportion of samples in which strata were present. Height and cover data are means with standard errors in parentheses (n=15).

Stratum	Frequency (%)	Height (m)	Cover (%)
Tree	100	19.2(1.1)	23(3)
Small tree	53.3	6.6(1.1)	21(7)
Shrub	93.3	2.0(0.5)	21(6)
Ground cover	100	0.6(0.1)	29(5)

Table 48c. Habitat characteristics of Map Unit 48. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5° and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		990	942–1031	19
Altitude (m)		330	215–450	19
Slope (degrees)		19	11–31	19
Terrain class				
North	21			4
Intermediate	47			9
South	11			2
Flat	21			4
Parent material				
Devonian granitoids	84			16
Devonian high quartz sedimentaries	11			2
Ordovician high quartz sedimentaries	5			1



Map 48. Distribution of samples of Mumbulla Dry Shrub Forest (Map Unit 48) shown by large black squares. Samples of other map units shown as small grey points.

Plate 48. Mumbulla Dry Shrub Forest (Map Unit 48) dominated by *Eucalyptus sieberi* with *E. agglomerata, Allocasuarina littoralis, Acacia obtusifolia* and *Lepidosperma urophorum* on Lizard Road, Biamanga National Park.

Map Unit 49: Coastal Dry Shrub Forest

Coastal Dry Shrub Forest is dominated by *Eucalyptus sieberi* and *E. agglomerata* c. 20 m tall, sometimes with an open stratum of small trees, *Allocasuarina littoralis* 8 m tall. It has an open sclerophyllous shrub stratum including *Acacia obtusifolia, Monotoca scoparia, Podolobium ilicifolium, Platysace lanceolata* and *Persoonia linearis.* Vines of *Billardiera scandens* twine amongst the shrubs. The sparse groundcover comprises sclerophyll herbs *Stylidium graminifolium, Dianella caerulea* and *Lepidosperma laterale.* Coastal Dry Shrub Forest is widespread on coastal mountain ridges, dry slopes and coastal plateaux on metasediments at 100–500 m elevation. It may occur up to 900 m elevation on hinterland mountains (Big Jack Mountain, Mt Poole) and in the dissected terrain north of Bemboka. It differs from the more restricted Mumbulla Dry Shrub

Forest (Map Unit 48) in understorey composition and subdominant tree species and occupies different substrates. Similar vegetation extends north of the Eden region in the dissected terrain of the Wadbilliga and Tuross River catchments (Austin 1978, CSIRO 1996). Although no similar assemblages have been explicitly described in East Gippsland (Forbes et al. 1982), one may exist within the lowland sclerophyll forest complex (Ecological Vegetation Class 16, Woodgate et al. 1994). Relatively little Coastal Dry Shrub Forest has been cleared. Although the largest area remains on State Forest, substantial areas occur on all tenures. Although some areas on private land may be threatened by clearing, the principal threat is frequent disturbance regimes that include logging (outside reserves) and fire in combination. These regimes reduce diversity by interrupting life-cycle processes of woody species (Keith 1996). Logging followed by regeneration burns and thinning may change the relative abundance of eucalypt species, particularly *E. sieberi* (Bridges 1983). Intervals between planned and unplanned disturbances need to be long enough to allow replenishment of seed banks and restoration of habitat structure if losses of diversity are to be avoided.

Species richness: 28 ± 1 (0.04 ha)

Extant area: 32 240 ha

Proportion cleared: 2%

Number of samples: 52

Table 49a. Diagnostic plant species of Map Unit 49.

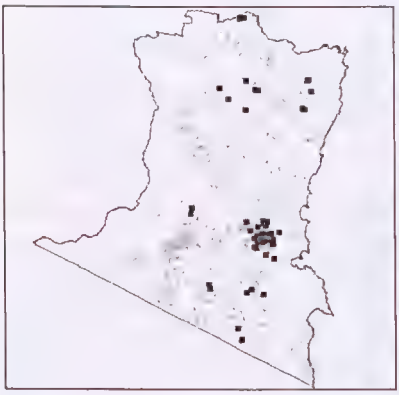
Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Acacia obtusifolia	0.667	2.5(2–3)	0.07	3(2–3)	positive
Allocasuarina littoralis	0.563	3(1–4)	0.151	2(1–3)	positive
Caleana major	0.021	1(1–1)	0	0(0–0)	positive
Eucalyptus agglomerata	0.75	3(2–3)	0.087	3(2–3)	positive
Eucalyptus sieberi	0.958	3(3–4)	0.26	3(2–4)	positive
Lobelia gibbosa	0.042	1(1–1)	0	0(0–0)	positive
Monotoca scoparia	0.625	2(1–2)	0.109	2(1–2)	positive
Podolobium ilicifolium	0.688	2(1–2)	0.059	1(1–2)	positive
Platysace lanceolata	0.771	2(2–2)	0.234	2(1–2)	positive
Stylidium graminifolium	0.5	2(1–2)	0.136	1(1–2)	positive
Billardiera scandens	0.708	1(1–1)	0.316	1(1–1)	frequent
Dianella caerulea	0.667	1(1–2)	0.265	1(1–2)	frequent
Lepidosperma laterale	0.604	1(1–1)	0.336	1(1–2)	frequent
Persoonia linearis	0.917	1(1–2)	0.265	1(1–2)	frequent
Angophora floribunda	0.146	1(1–1)	0.093	2(1–3)	uninformative
Corymbia gummifera	0.063	1(1–3)	0.019	3(2–4)	uninformative
Eucalyptus angophoroides	0.021	3(3–3)	0.045	2(1–3)	uninformative
Eucalyptus cypellocarpa	0.042	1(1–1)	0.323	3(2–3)	uninformative
Eucalyptus elata	0.021	1(1–1)	0.116	3(2–3)	uninformative
Eucalyptus globoidea	0.021	1(1–1)	0.25	3(1–3)	uninformative
Eucalyptus muelleriana	0.063	2(1–3)	0.145	3(3–4)	uninformative
Eucalyptus obliqua	0.021	1(1–1)	0.195	3(2–4)	uninformative
Eucalyptus smithii	0.083	1.5(1–3)	0.044	2(1–3)	uninformative
Eucalyptus tricarpa	0.021	1(1–1)	0.022	2(1–3)	uninformative
Lomandra longifolia	0.271	1(1–2)	0.558	2(1–2)	negative
Poa meionectes	0.188	2(1–2)	0.551	2(1–3)	negative
Pteridium esculentum	0.458	2(1–2)	0.581	2(1–3)	negative

Table 49b. Vegetation structure of Map Unit 49. Frequency is the proportion of samples in which strata were present. Height and cover data are means with standard errors in parentheses (n=24).

Stratum	Frequency (%)	Height (m)	Cover (%)
Tree	100	21.5(0.9)	29(2)
Small tree	58.3	8.6(0.9)	17(4)
Shrub	95.8	2.0(0.3)	21(3)
Ground cover	100	0.6(0.1)	14(3)

Table 49c. Habitat characteristics of Map Unit 49. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5° and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		954	898–992	53
Altitude (m)		399	245–545	51
Slope (degrees)		16	10–22	50
Terrain class				
North	30			15
Intermediate	50			25
South	16			8
Flat	4			2
Parent material				
Devonian granitoids	15			8
Devonian high quartz sedimentaries	40			21
Devonian rhyolite	8			4
Low quartz sedimentaries	26			14
Ordovician high quartz sedimentaries	11			6



Map 49. Distribution of samples of Coastal Dry Shrub Forest (Map Unit 49) shown by large black squares. Samples of other map units shown as small grey points.

Plate 49. Coastal Dry Shrub Forest (Map Unit 49) dominated by *Eucalyptus sieberi* with *Acacia obtusifolia, Tetratheca thymifolia, Podolobium ilicifolium, Coopernookia barbata* and *Lomandra multiflora* on Sugarloaf Road, near The Sugarloaf, Yowaka section of South East Forests National Park.

Map Unit 50: Genoa Dry Shrub Forest

Genoa Dry Shrub Forest is dominated by *Eucalyptus agglomerata* and several minor tree species 17 m tall. It has a prominent sclerophyllous shrub stratum including *Acacia falciformis, A. terminalis, Monotoca scoparia, Podolobium ilicifolium, Persoonia linearis, Platysace lanceolata, Cassinia longifolia* and *Lomatia ilicifolia.* The sparse groundcover comprises grasses and graminoids *Chionochloa pallida, Caustis flexuosa* and *Lomandra longifolia,* herbs *Pomax umbellata* and sprawling vines of *Hardenbergia violacea.* Genoa Dry Shrub Forest is restricted to dry ridges and slopes on sandstone terrain at 300–740 m around the Genoa River and on Mt Imlay. Although no similar assemblages have been explicitly described outside the Eden region (Austin 1978, Forbes et al. 1982), Genoa Dry Shrub Forest is likely to extend across the Victorian border in the Genoa sandstone terrain within Coopracambra National Park. About one-fifth of this assemblage has been cleared for pine plantations, most of the remainder being reserved while about one-third occurs within production forest on private or public land. The principal threat is frequent disturbance regimes that include logging (outside reserves) and fire in combination. These regimes reduce diversity by interrupting life-cycle processes of woody species (Keith 1996). Intervals between planned and unplanned disturbances need to be long enough to allow replenishment of seed banks and restoration of habitat structure if losses of diversity are to be avoided.

Species richness: 21 ± 3 (0.04 ha)
Extant area: 3022 ha
Proportion cleared: 18%
Number of samples: 5

Table 50a. Diagnostic plant species of Map Unit 50.

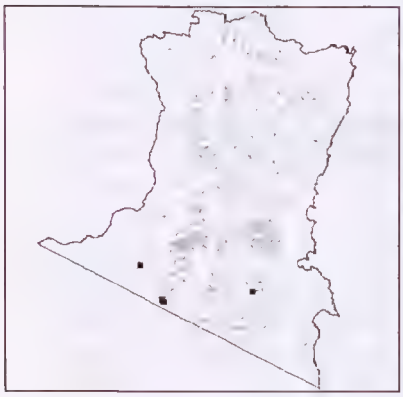
Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Acacia falciformis	0.8	2(2–4)	0.188	2(1–3)	positive
Acacia terminalis	0.6	3(2–3)	0.118	2(1–3)	positive
Chionochloa pallida	0.8	2.5(1–3)	0.102	2(2–3)	positive
Eucalyptus agglomerata	0.8	4(3–4)	0.106	3(2–3)	positive
Monotoca scoparia	1	3(2–3)	0.123	2(1–2)	positive
Podolobium ilicifolium	0.8	2(1–3)	0.077	1(1–2)	positive
Persoonia linearis	0.8	2.5(1–3)	0.284	1(1–2)	positive
Platysace lanceolata	1	2(2–2)	0.249	2(1–2)	positive
Pomax umbellata	0.8	2.5(1–3)	0.048	1(1–2)	positive
Lomandra longifolia	0.6	2(2–2)	0.549	2(1–2)	frequent
Cassinia longifolia	0.6	1(1–1)	0.187	1(1–2)	frequent
Caustis flexuosa	0.6	1(1–3)	0.037	2(1–2)	frequent
Hardenbergia violacea	0.6	1(1–3)	0.099	1(1–1)	frequent
Lomatia ilicifolia	0.8	1(1–2)	0.129	1(1–2)	frequent
Eucalyptus angophoroides	0.2	1(1–1)	0.044	2(1–3)	uninformative
Eucalyptus globoidea	0.2	3(3–3)	0.243	3(1–3)	uninformative
Eucalyptus mackintii	0.2	4(4–4)	0.003	3(3–4)	uninformative
Eucalyptus radiata	0.2	3(3–3)	0.076	3(1–3)	uninformative
Poa meionectes	0.2	1(1–1)	0.54	2(1–3)	negative
Pteridium esculentum	0.4	1.5(1–2)	0.577	2(1–3)	negative

Table 50b. Vegetation structure of Map Unit 50. Frequency is the proportion of samples in which strata were present. Height and cover data are means with standard errors in parentheses (n=5).

Stratum	Frequency (%)	Height (m)	Cover (%)
Tree	100	17.4(1.3)	32(5)
Small tree	40	3.8(1.3)	18(3)
Shrub	100	1.2(0.3)	32(12)
Ground cover	100	0.4(0.1)	18(4)

Table 50c. Habitat characteristics of Map Unit 50. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5° and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		957	938–981	5
Altitude (m)		456	360–465	
Slope (degrees)		26	21–29	5
Terrain class				
North	40			2
Intermediate	60			3
South	0			0
Flat	0			0
Parent material				
Devonian high quartz sedimentaries	80			4
Ordovician high quartz sedimentaries	20			1



Map 50. Distribution of samples of Genoa Dry Shrub Forest (Map Unit 50) shown by large black squares. Samples of other map units shown as small grey points.

Plate 50. Genoa Dry Shrub Forest (Map Unit 50) dominated by *Eucalyptus mackintii* with *E. agglomerata* and *E. dives* and a shrubby understorey of *Hakea decurrens* ssp. *physocarpa, Leucopogon microphyllus, Caustis flexuosa* and *Pteridium esculentum* in the Genoa River gorge, Genoa section of South East Forests National Park.

Map Unit 51: Rhyolite Rock Scrub

Rhyolite Rock Scrub is dominated by dense but patchy shrub strata, 2–7 m tall, including *Kunzea ambigua, Melaleuca armillaris, Phebalium ralstonii, Platysace lanceolata, Pultenaea retusa* and *Westringia davidii.* Occasionally emergent small trees include *Allocasuarina littoralis* or rarely *Eucalyptus sieberi, E. agglomerata* and other eucalypt species. The groundcover comprises scattered tussocks of grasses and graminoids *Thonandia longifolia, Lepidosperma laterale, L. urophorum* and *Entolasia stricta,* and the lilioid herb *Stypandra glauca.* Rhyolite Rock Scrub is restricted to skeletal soils on

outcrops of rhyolite at 100–400 m elevation on the coastal range west of Pambula. This assemblage contains a large number of rare, threatened and locally endemic species and is unique to the Eden region. Another rhyolite scrub assemblage with a different complement of rare and threatened species occurs to the north in Deua National Park. The highly restricted stands of Rhyolite Rock Scrub occur on all tenures and, although none have been cleared, they are threatened by grazing and frequent fire regimes. Occurrences on private land are subject to grazing by domestic goats, while feral goats potentially threaten stands on all tenures. Frequent fires used in hazard reduction or grazing management may reduce diversity by interrupting life-cycle processes of woody species (Keith 1996). Intervals between planned and unplanned fires need to be long enough to allow replenishment of seed banks and restoration of habitat structure if losses of diversity are to be avoided. Post-fire seedling recruitment in shrub populations may be poor on skeletal soils if drought follows fire. Long fire-free intervals also potentially threaten Rhyolite Rock Scrub if the length of intervals exceeds the combined longevity of standing plants and seed banks. Nevertheless, particular care is needed to avoid the escape of hazard reduction fires onto the outcrops from adjacent production forest and grazing areas.

Species richness: 34 ± 4 (0.04 ha)

Extant area: 51 ha

Proportion cleared: 0%

Number of samples: 14

Table 51a. Diagnostic plant species of Map Unit 51.

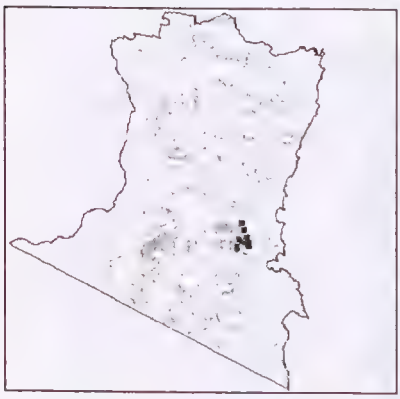
Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Acacia subtilinervis	0.143	2(2–2)	0	0(0–0)	positive
Calochilus robertsonii	0.071	1(1–1)	0	0(0–0)	positive
Cryptandra amara	0.071	3(3–3)	0	0(0–0)	positive
Kunzea ambigua	0.857	3(3–3)	0.023	2(1–3)	positive
Lepidosperma laterale	0.643	2(1–2)	0.342	1(1–2)	positive
Melaleuca armillaris	0.929	3(2–3)	0.022	3(1–4)	positive
Mirbelia pungens	0.071	1(1–1)	0	0(0–0)	positive
Myriophyllum propinquum	0.071	1(1–1)	0	0(0–0)	positive
Phebalium ralstonii	0.786	2(1–2)	0.003	1(1–3)	positive
Platysace lanceolata	0.929	2(2–2)	0.245	2(1–2)	positive
Prasophyllum rhyoliticum	0.071	1(1–1)	0	0(0–0)	positive
Prostanthera phylicifolia	0.071	3(3–3)	0	0(0–0)	positive
Pultenaea retusa	0.571	2(1–2)	0.019	1(1–2)	positive
Sticherus flabellatus	0.071	1(1–1)	0	0(0–0)	positive
Thonandia longifolia	0.714	2(1–2)	0.07	1(1–2)	positive
Westringia davidii	0.286	2(1–3)	0	0(0–0)	positive
Allocasuarina littoralis	0.929	1(1–2)	0.157	2(1–3)	frequent
Entolasia stricta	0.786	1(1–2)	0.176	1.5(1–2)	frequent
Lepidosperma urophorum	0.786	1(1–2)	0.064	1(1–2)	frequent
Stypandra glauca	0.643	1(1–1)	0.021	1(1–2)	frequent
Eucalyptus agglomerata	0.286	1(1–3)	0.107	3(2–3)	uninformative
Eucalyptus elata	0.071	1(1–1)	0.113	3(2–3)	uninformative
Eucalyptus sieberi	0.357	2(1–3)	0.282	3(2–4)	uninformative
Eucalyptus smithii	0.214	2(1–2)	0.044	2(1–3)	uninformative
Lomandra longifolia	0.214	2(1–3)	0.552	2(1–2)	negative
Poa meionectes	0.357	1(1–2)	0.541	2(1–3)	negative
Pteridium esculentum	0.143	1.5(1–2)	0.581	2(1–3)	negative

Table 51b. Vegetation structure of Map Unit 51. Frequency is the proportion of samples in which strata were present. Height and cover data are means with standard errors in parentheses (n=14).

Stratum	Frequency (%)	Height (m)	Cover (%)
Tree	57.1	14.4(2.0)	7(2)
Small tree	71.4	6.9(0.8)	18(6)
Shrub	100	2.6(0.3)	32(6)
Ground cover	100	0.6(0.1)	8(3)

Table 51c. Habitat characteristics of Map Unit 51. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5° and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		937	881–969	14
Altitude (m)		314	210–408	14
Slope (degrees)		22	10–31	14
Terrain class				
North	36			5
Intermediate	29			4
South	14			2
Flat	21			3
Parent material				
Devonian rhyolite	100			14



Map 51. Distribution of samples of Rhyolite Rock Scrub (Map Unit 51) shown by large black squares. Samples of other map units shown as small grey points.

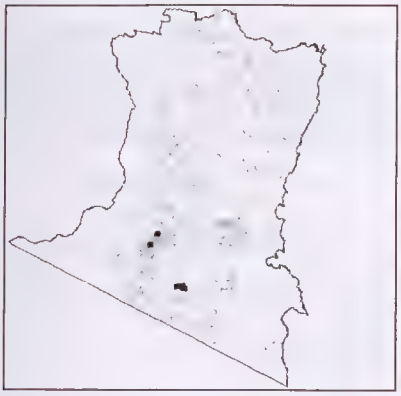
Plate 51. Rhyolite Rock Scrub (Map Unit 51) open variant with *Xanthorrhoea australis*, scattered *Eucalyptus sieberi* and *Kunzea ambigua* on The Sugarloaf, Yowaka section of South East Forests National Park.

Map Unit 52: Mountain Rock Scrub

Mountain Rock Scrub is dominated by a dense but patchy shrub stratum 4 m tall, including *Kunzea ambigua, Hakea macreana* with *Acacia longifolia, Correa reflexa, Goodenia ovata, Grevillea victoriae and Platysace lanceolata.* Occasionally emergent small trees include *Eucalyptus smithii* and *E. sieberi*. The groundcover comprises scattered tussocks of graminoids *Lepidosperma laterale, L. urophorum* and *Lomandra glauca,* and the lilioid herb *Stypandra glauca.* Mountain Rock Scrub is restricted to skeletal soils on granitoid

outcrops at 500–1000 m elevation on hinterland and escarpment mountains in the south-west (e.g. Mt Poole, White Rock Mountain, Pheasants Peak). This assemblage lacks the compliment of rare, threatened and endemic plant species characteristic of the lower elevation rhyolite outcrops (Map Unit 51), as well as including some shrub species that are absent from that assemblage. A similar assemblage has a restricted distribution on granitoid peaks in East Gippsland including Maramingo Hill, Genoa Peak and Mt Kaye. This assemblage is included within Rocky Outcrop Shrubland (Ecological Vegetation Class 28, Woodgate et al. 1994), along with other assemblages on non-granitoid substrates that share few species in common. Mountain Rock Scrub remains uncleared and is almost entirely contained within reserves. Frequent regimes fire may reduce diversity by interrupting life-cycle processes of woody species (Keith 1996). Intervals between planned and unplanned fires need to be long enough to allow replenishment of seed banks and restoration of habitat structure if losses of diversity are to be avoided. Post-fire seedling recruitment in shrub populations may be poor on skeletal soils if drought follows fire. Long fire-free intervals also potentially threaten Mountain Rock Scrub if the length of intervals exceeds the combined longevity of standing plants and seed banks. The level of grazing by feral goats is unknown, but potentially problematic.

Species richness: 24 ± 2 (0.04 ha)
Extant area: 202 ha
Proportion cleared: 0%
Number of samples: 8



Map 52. Distribution of samples of Mountain Rock Scrub (Map Unit 52) shown by large black squares. Samples of other map units shown as small grey points.

Plate 52. Mountain Rock Scrub (Map Unit 52) with clumped stands of *Melaleuca armillaris* and *Kunzea ambigua* with *Epacris microphylla* and *Lepidosperma gunnii* on massive granitoid outcrops near Mt Poole, Mt Poole Flora Reserve.

Table 52a. Diagnostic plant species of Map Unit 52.

Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Acacia longifolia	0.625	2(2–2)	0.138	2(1–3)	positive
Boronia anemonifolia	0.125	2(2–2)	0	0(0–0)	positive
Bulbostylis barbata	0.125	1(1–1)	0	0(0–0)	positive
Calandrinia calyptrata	0.125	1(1–1)	0	0(0–0)	positive
Correa reflexa	0.875	2(1–2)	0.123	1(1–2)	positive
Eucalyptus smithii	0.5	2(2–3)	0.043	2(1–3)	positive
Goodenia ovata	0.75	2(1–2)	0.17	2(1–3)	positive
Grevillea victoriae var. *leptoneura*	0.5	2(2–3)	0.01	2(1–3)	positive
Hakea macraeana	0.5	2.5(2–4)	0.035	1(1–2)	positive
Hierochloe rariflora	0.5	2(1–2)	0.18	2(1–3)	positive
Kunzea ambigua	0.625	4(3–6)	0.028	2(1–3)	positive
Lepidosperma laterale	0.875	2(2–2)	0.342	1(1–2)	positive
Pomaderris prunifolia	0.125	1(1–1)	0	0(0–0)	positive
Stypandra glauca	0.75	2(2–2)	0.023	1(1–2)	positive
Lomandra longifolia	0.625	2(2–2)	0.549	2(1–2)	frequent
Eucalyptus sieberi	0.75	1(1–2)	0.28	3(2–4)	frequent
Lepidosperma urophorum	0.75	1.5(1–2)	0.068	1(1–2)	frequent
Platysace lanceolata	0.75	1(1–2)	0.249	2(1–2)	frequent
Eucalyptus elata	0.125	1(1–1)	0.113	3(2–3)	uninformative
Eucalyptus globoidea	0.125	1(1–1)	0.243	3(1–3)	uninformative
Poa meionectes	0.125	1(1–1)	0.541	2(1–3)	negative
Pteridium esculentum	0	0(2–0)	0.58	2(1–3)	negative

Table 52b. Vegetation structure of Map Unit 52. Frequency is the proportion of samples in which strata were present. Height and cover data are means with standard errors in parentheses (n=3).

Stratum	Frequency (%)	Height (m)	Cover (%)
Tree	0	-(-)	-(-)
Small tree	66.7	13.5(1.5)	8(3)
Shrub	100	4.0(1.0)	47(14)
Ground cover	100	0.5(0.0)	15(8)

Table 52c. Habitat characteristics of Map Unit 52. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5° and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		1134	1126–1166	8
Altitude (m)		749	660–770	8
Slope (degrees)		39	30–46	4
Terrain class				
North	75			3
Intermediate	25			1
South	0			0
Flat	0			0
Parent material				
Devonian granitoids	100			8

Map Unit 53: Montane Heath

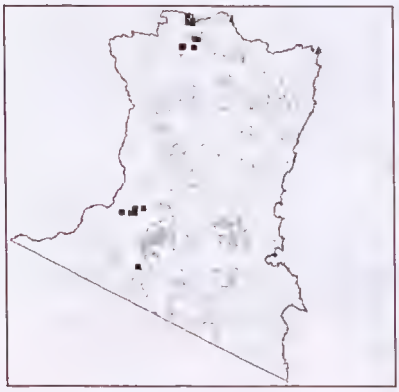
Montane Heath is dominated by a closed shrub canopy of *Allocasuarina nana* exceeding 1 m in height. Other shrubs include *Brachyloma daphnoides, Hakea dactyloides, Baeckea denticulata* and *Kunzea* spp. with several infrequent species. A sparse scattering of eucalypt saplings 10 m tall emerges from the shrub canopy. The groundcover comprises scattered tussocks of grasses and graminoids *Chionochloa pallida, Notodanthonia tenuoir, Austrostipa pubinodis* and *Lomandra glauca.* Montane Heath is restricted to two disjunct occurrences on the edge of the Monaro Tableland: the upper Tuross and Numeralla Rivers area in the north-west; and the Bombala area in the south-west. It occurs on skeletal soils derived from metamorphosed sediments typically above 700 m elevation, although an unusual stand occurs on a granitoid substrate at 560 m elevation in the White Rock River area. The northern heathlands contain a number of species absent from those around Bombala, including *Acacia lucassii, Banksia canei, Dampiera fusca, Dillwynia phylicoides* and *Kunzea* sp. C. While no similar assemblages occur in East Gippsland (Woodgate et al. 1994), patches of montane heathlands extend further north along the escarpment range into Deua National Park. Less than 10% of Montane Heath has been cleared for pine plantations or rough grazing. Further clearing and grazing potentially threatens some of the remainder on private and leasehold land in the Numeralla area. Extreme fire frequencies if sustained, may threaten stands on all tenures, particularly where Montane Heath adjoins pine plantations or grazing lands. Frequent regimes fire may reduce diversity by interrupting life-cycle processes of woody species (Keith 1996). The absence of serotinous obligate seeders, such as *Banksia canei, Hakea dactyloides* and *Allocasuarina distyla*, from Montane Heath around Bombala (cf. Wadbilliga) may be a consequence of such regimes in this area during the last 150 years (Banks 1990). Intervals between planned and unplanned fires need to be long enough to allow replenishment of seed banks and restoration of habitat structure if losses of diversity are to be avoided. Post-fire seedling recruitment in shrub populations may be poor on skeletal soils if drought follows fire. The risk of recruitment failure is greater under frequent fire regimes. Long fire-free intervals also potentially threaten Montane Heath if the length of intervals exceeds the combined longevity of standing plants and seed banks.

Species richness: 17 ± 2 (0.04 ha)
Extant area: 3025 ha
Proportion cleared: 7%
Number of samples: 21

Table 53a. Diagnostic plant species of Map Unit 53.

Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Acacia lucassii	0.143	1(1–3)	0	0(0–0)	positive
Allocasuarina nana	1	6(6–6.5)	0.005	3(1–3)	positive
Aristida jerichoensis var. *jerichoensis*	0.048	1(1–1)	0	0(0–0)	positive
Baeckea denticulata	0.238	3(2.5–3.5)	0	0(0–0)	positive
Boronia algida	0.143	1(1–3)	0	0(0–0)	positive
Brachyloma daphnoides	0.857	2(1–2)	0.018	1(1–2)	positive
Chionochloa pallida	0.524	2(1–3)	0.099	2(2–3)	positive

Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Chloanthes parviflora	0.095	3(2–4)	0	0(0–0)	positive
Dampiera fusca	0.191	1(1–2)	0	0(0–0)	positive
Deyeuxia parviseta var. *boormanii*	0.191	1(1–1)	0	0(0–0)	positive
Dillwynia phylicoides	0.095	3(2–4)	0	0(0–0)	positive
Hakea dactyloides	0.524	2(1–4)	0.007	2(1–2)	positive
Haloragodendron monospermum	0.238	2(1–4.5)	0	0(0–0)	positive
Hibbertia pedunculata	0.333	3(1–4)	0	0(0–0)	positive
Kunzea parvifolia	0.095	2(2–2)	0	0(0–0)	positive
Kunzea sp. C	0.288	3(2–4)	0	0(0–0)	positive
Lomandra glauca	0.619	2(1–3)	0.036	1(1–2)	positive
Patersonia longifolia	0.191	1(1–2.5)	0	0(0–0)	positive
Poa sieberiana var. *cyanophylla*	0.095	1(1–1)	0	0(0–0)	positive
Austrostipa pubinodis	0.571	2(1–3)	0.006	1.5(1–2)	positive
Notodanthonia tenuior	0.524	1(1–1)	0.002	1(1–2)	frequent
Banksia canei	0.191	3(1–5)	0.001	3.5(3–4)	uninformative
Eucalyptus consideniana	0.048	2(2–2)	0.021	2(1–3)	uninformative
Eucalyptus dalrympleana subsp. *dalrympleana*	0.048	1(1–1)	0.018	2.5(1–3)	uninformative
Eucalyptus dives	0.143	1(1–4)	0.009	3(2.5–3)	uninformative
Eucalyptus pauciflora	0.191	1(1–2)	0.021	2.5(1–3)	uninformative
Eucalyptus rubida	0.095	1(1–1)	0.006	1(1–3)	uninformative
Eucalyptus sieberi	0.048	3(3–3)	0.286	3(2–4)	uninformative
Gonocarpus tetragynus	0.57	1(1–2)	0.16	2(1–2)	uninformative
Isopogon prostratus	0.238	3(1–3)	0.001	1(1–1)	uninformative
Lepidosperma gunnii	0.524	1(1–2)	0.004	1(1–2)	uninformative
Persoonia chamaepeuce	0.238	1(1–2)	0.008	1(1–2)	uninformative
Schoenus apogon	0.238	2(1.5–3)	0.023	1(1–2)	uninformative
Stylidium graminifolium	0.81	1(1–3)	0.139	1(1–2)	uninformative
Lomandra longifolia	0.333	1(1–1)	0.552	2(1–2)	negative
Poa meionectes	0	0(0–0)	0.547	2(1–3)	negative
Pteridium esculentum	0	0(0–0)	0.585	2(1–3)	negative



Map 53. Distribution of samples of Montane Heath (Map Unit 53) shown by large black squares. Samples of other map units shown as small grey points.

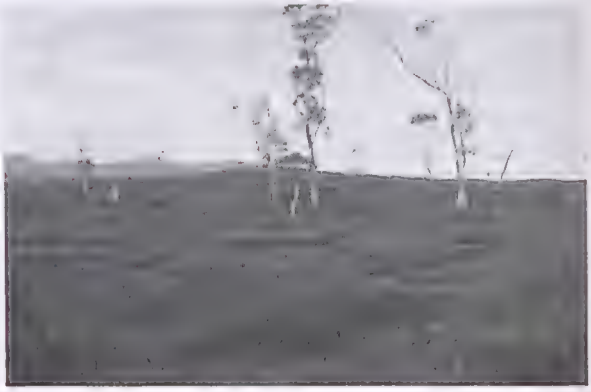


Plate 53. Montane Heath (Map Unit 53) dominated by *Allocasuarina nana* with *Brachyloma daphnoides*, *Notodanthonia tenuior* and scattered emergent *Eucalyptus dalrympleana* on Bald Hill, Bondi Gulf Nature Reserve.

Table 53b. Vegetation structure of Map Unit 53. Frequency is the proportion of samples in which strata were present. Height and cover data are means with standard errors in parentheses (n=21).

Stratum	Frequency (%)	Height (m)	Cover (%)
Tree	14.3	10.0(2.9)	15(10)
Small tree	19	1.3(0.1)	3(1)
Shrub	100	1.3(0.2)	86(3)
Ground cover	100	0.3(0.0)	7(2)

Table 53c. Habitat characteristics of Map Unit 53. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5° and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°). One extreme value was excluded from the summary statistics for annual rain (1004 mm).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		815	799–814	19
Altitude (m)		950	818–1060	20
Slope (degrees)		10	4–15	21
Terrain class				
North	29			6
Intermediate	38			8
South	5			1
Flat	29			6
Parent material				
Devonian granitoids	5			1
Devonian high quartz sedimentaries	14			3
Low quartz sedimentaries	52			11
Ordovician high quartz sedimentaries	29			6

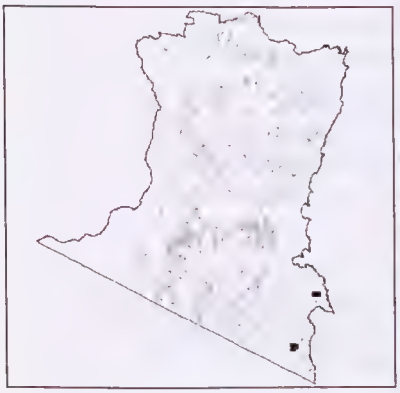
Map Unit 54: Mt Nadgee Heath

Mt Nadgee Heath has an open shrub canopy over 1 m tall, dominated by *Leptospermum trinervium* and *Banksia paludosa* with *Dillwynia glaberrima, Epacris impressa, E. microphylla, Aotus ericoides, Leptospermum continentale, Leucopogon esquamatus, Monotoca scoparia* and *Persoonia levis*. Scattered individuals of *Eucalyptus baxteri* emerge from the shrub stratum. The groundcover is dominated by sedges *Lepidosperma filiforme, L. gladiatum, L. neesii, Lepyrodia scariosa, Gahnia sieberiana* and *Lomandra glauca*, with grasses *Plinthanthesis paradoxa*, herbs *Gonocarpus tetragynus, Dampiera stricta* and *Xanthosia pilosa* and small ferns *Lindsaea linearis*. Swards of *Xanthorrhoea resinifera* occur in damper sites. Mt Nadgee Heath is restricted to rocky Devonian sandstone plateaux around Mt Nadgee and west of Green Cape at elevations up to 450 m and possibly on damper soils than Coastal Lowland Heath (Map Unit 55). No similar assemblages occur outside the Eden region (Austin 1978, Woodgate et al. 1994). Almost all of this restricted unit occurs in reserves. Frequent fire regimes may reduce diversity by interrupting life-cycle processes of woody species (Keith 1996). Intervals between planned and unplanned fires need to be long enough to allow replenishment of seed banks and restoration of habitat structure if losses of diversity are to be avoided.

Species richness: 37 ± 3 (0.04 ha)
Extant area: 371 ha
Proportion cleared: 0%
Number of samples: 6

Table 54a. Diagnostic plant species of Map Unit 54.

Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Acacia terminalis	0.5	2(1–3)	0.118	2(1–3)	positive
Baeckea linifolia	0.167	1(1–1)	0	0(0–0)	positive
Banksia paludosa	0.833	3(2–3)	0.007	2.5(1–3)	positive
Baumea acuta	0.167	2(2–2)	0	0(0–0)	positive
Bossiaea heterophylla	0.5	2(1–2)	0.002	2(1–2)	positive
Conospermum taxifolium	0.333	1.5(1–2)	0	0(0–0)	positive
Dillwynia glaberrima	0.667	2(2–2)	0.006	2(1–3)	positive
Epacris impressa	0.833	2(2–3)	0.194	2(1–2)	positive
Epacris microphylla var. *microphylla*	0.667	3(2–3)	0.01	1.5(1–3)	positive
Eucalyptus baxteri	0.833	3(2–3)	0.005	3(2–4)	positive
Gonocarpus tetragynus	0.667	2(2–2)	0.164	2(1–2)	positive
Lepidosperma filiforme	0.667	2(1–3)	0.014	2(2–3)	positive
Lepidosperma gladiatum	0.667	2.5(1–4)	0.003	1(1–1)	positive
Lepidosperma neesii	0.667	2(2–3)	0.008	2.5(1–3)	positive
Leptospermum trinervium	1	3(2–4)	0.026	2(1–3)	positive
Lindsaea linearis	0.833	2(2–2)	0.029	1(1–2)	positive
Lomandra glauca	0.667	2(2–3)	0.042	1(1–2)	positive
Phebalium diosmeum	0.667	2.5(1–3)	0.002	3(1–3)	positive
Plinthanthesis paradoxa	0.667	2(1–2)	0.002	1(1–2)	positive
Lomandra longifolia	0.5	2(1–3)	0.549	2(1–2)	frequent
Aotus ericoides	0.667	1.5(1–2)	0.024	1(1–2)	frequent
Cassytha glabella	1	1(1–2)	0.019	1(1–2)	frequent
Dampiera stricta	0.833	1(1–2)	0.029	1(1–2)	frequent
Gahnia sieberiana	0.667	1(1–2)	0.074	1(1–3)	frequent



Map 54. Distribution of samples of Mt Nadgee Heath (Map Unit 54) shown by large black squares. Samples of other map units shown as small grey points.

Plate 54. Mt Nadgee Heath (Map Unit 54) dominated by *Allocasuarina nana* with *A. paludosa, Leptospermum trinervium, Leucopogon esquamatus, Lepidosperma concava* and emergent *Eucalyptus baxteri* on Mt Nadgee plateau, Nadgee Nature Reserve.

Leptospermum continentale	0.667	1(1–2)	0.056	1(1–2)	frequent
Lepyrodia scariosa	0.833	1(1–3)	0.002	1(1–3)	frequent
Leucopogon esquamatus	0.667	1.5(1–3)	0.001	2(1–3)	frequent
Monotoca scoparia	0.667	1(1–2)	0.124	2(1–2)	frequent
Persoonia levis	1	1(1–2)	0.023	1(1–1)	frequent
Xanthosia pilosa	0.667	1.5(1–2)	0.057	1(1–2)	frequent
Angophora floribunda	0.167	1(1–1)	0.095	2(1–3)	uninformative
Banksia serrata	0.333	3(3–3)	0.04	1(1–2)	uninformative
Eucalyptus sieberi	0.5	1(1–2)	0.282	3(2–4)	uninformative
Poa meionectes	0	0(1–0)	0.541	2(1–3)	negative
Pteridium esculentum	0.167	2(2–2)	0.578	2(1–3)	negative

Table 54b. Vegetation structure of Map Unit 54. Frequency is the proportion of samples in which strata were present. Height and cover data are means with standard errors in parentheses (n=6).

Stratum	Frequency (%)	Height (m)	Cover (%)
Tree	83.3	12.2(4.4)	10(2)
Small tree	50	5.3(1.8)	32(2)
Shrub	100	1.2(0.4)	43(7)
Ground cover	100	0.5(0.1)	33(4)

Table 54c. Habitat characteristics of Map Unit 54. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5° and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		1013	930–1088	6
Altitude (m)		283	159–389	6
Slope (degrees)		5	3–8	6
Terrain class				
North	0			0
Intermediate	33			2
South	0			0
Flat	67			4
Parent material				
Devonian high quartz sedimentaries	100			6

Map Unit 55: Coastal Lowland Heath

Coastal Lowland Heath has a diverse open shrub canopy up to 1 m tall, dominated by *Allocasuarina paludosa, Banksia paludosa* and *Epacris impressa* with *Acacia suaveolens, Cryptandra ericoides, Hakea decurrens* subsp. *platytaena, Leptospermum continentale, Pimelea linifolia* and *Banksia serrata,* the latter sometimes emerging as small trees with occasional eucalypts 5 m tall. The relatively dense and diverse groundcover is dominated by sedges *Hypolaena fastigiata, Lepidosperma neesii, Leptocarpus tenax* and *Lomandra glauca,* with distinctive herbs including *Burchardia umbellata, Helichrysum obtusifolium, Dampiera stricta, Patersonia glabrata, Xanthosia tridentata* and *X. pusilla,* grasses *Entolasia stricta,* herbs *Gonocarpus tetragynus, Dampiera stricta* and *Xanthosia pilosa* and small ferns *Lindsaea linearis* and *Selaginella uliginosa.* Coastal Lowland Heath is restricted to gentle slopes on coastal deposits of Tertiary alluvium and Recent sands below 100 m elevation south from Pambula. It is distinguished from Mt Nadgee Heath by several shrub and herb species which are apparently unique to the lowland assemblage. Unlike Mt Nadgee Heath, the mainly continuous vegetation cover is not

punctuated by outcrops of rock. Although not known further north (Austin 1978), a similar assemblage extends to the south along the East Gippsland coastal plain (Ecological Vegetation Classes 7 and 8, Woodgate et al. 1994). Almost all of this restricted unit occurs within reserves. Frequent regimes fire may reduce diversity by interrupting life-cycle processes of woody species (Keith 1996). Intervals between planned and unplanned fires need to be long enough to allow replenishment of seed banks and restoration of habitat structure if losses of diversity are to be avoided.

Species richness: 35 ± 4 (0.04 ha)

Extant area: 1582 ha

Proportion cleared: 2%

Number of samples: 8

Table 55a. Diagnostic plant species of Map Unit 55.

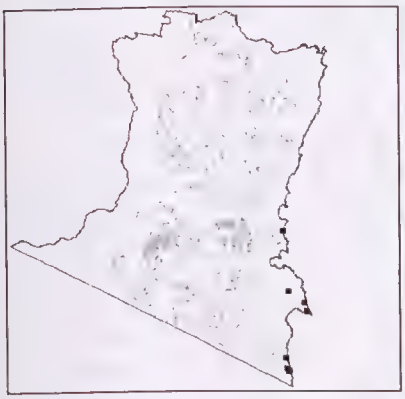
Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Acacia suaveolens	0.5	2(1–2)	0.013	1(1–2)	positive
Allocasuarina paludosa	0.75	4(2–5)	0.014	3(1–4)	positive
Almaleea paludosa	0.125	2(2–2)	0	0(0–0)	positive
Banksia paludosa	0.75	3(1–3)	0.006	2(2–3)	positive
Burchardia umbellata	0.625	2(1–2)	0.018	1(1–1)	positive
Cryptandra ericoides	0.5	2(1–3)	0.002	1(1–1)	positive
Epacris impressa	0.875	3(2–3)	0.193	2(1–2)	positive
Euphrasia collina subsp. *collina*	0.25	1.5(1–2)	0	0(0–0)	positive
Hakea decurrens subsp. *platytaena*	0.5	2.5(1–3)	0.022	1(1–2)	positive
Helichrysum obtusifolium	0.375	3(3–3)	0	0(0–0)	positive
Hypolaena fastigiata	0.625	2(2–3)	0.002	1(1–2)	positive
Lepidosperma neesii	0.75	2.5(1–3)	0.007	2(2–3)	positive
Leptocarpus tenax	0.5	3(2–5)	0.005	3(2–3)	positive
Leptospermum continentale	0.875	2(1–3)	0.054	1(1–2)	positive
Lindsaea linearis	0.625	2(1–2)	0.029	1(1–2)	positive
Lomandra glauca	0.875	2(1–2)	0.04	1(1–2)	positive
Mirbelia rubiifolia	0.25	1.5(1–2)	0	0(0–0)	positive
Patersonia glabrata	0.5	2(1–3)	0.065	1(1–2)	positive
Persoonia juniperina	0.125	1(1–1)	0	0(0–0)	positive
Ptilothrix deusta	0.125	2(2–2)	0	0(0–0)	positive
Thysanotus juncifolius	0.125	1(1–1)	0	0(0–0)	positive
Xanthosia pusilla	0.375	2(1–2)	0	0(0–0)	positive
Xanthosia tridentata	0.5	2(2–3)	0.018	1(1–2)	positive
Banksia serrata	0.75	1(1–2)	0.038	1(1–2)	frequent
Cassytha glabella	0.75	1(1–2)	0.019	1(1–2)	frequent
Dampiera stricta	0.625	1(1–2)	0.029	1(1–2)	frequent
Entolasia stricta	0.625	1(1–1)	0.179	2(1–2)	frequent
Pimelea linifolia subsp. *linifolia*	0.75	1(1–2)	0.033	1(1–2)	frequent
Selaginella uliginosa	0.625	1(1–3)	0.008	2(1–3)	frequent
Callitris rhomboidea	0.125	2(2–2)	0.003	1(1–2)	uninformative
Corymbia gummifera	0.125	1(1–1)	0.02	3(2–4)	uninformative
Eucalyptus conspicua	0.125	3(3–3)	0.001	1.5(1–2)	uninformative
Eucalyptus globoidea	0.125	3(3–3)	0.243	3(1–3)	uninformative
Lomandra longifolia	0	0(1–0)	0.552	2(1–2)	negative
Poa meionectes	0	0(1–0)	0.542	2(1–3)	negative
Pteridium esculentum	0	0(1–0)	0.58	2(1–3)	negative

Table 55b. Vegetation structure of Map Unit 55. Frequency is the proportion of samples in which strata were present. Height and cover data are means with standard errors in parentheses (n=8).

Stratum	Frequency (%)	Height (m)	Cover (%)
Tree	-	-(-)	-(-)
Small tree	12.5	5.0(-)	15(-)
Shrub	100	0.8(0.2)	59(9)
Ground cover	100	0.4(0.0)	53(10)

Table 55c. Habitat characteristics of Map Unit 55. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5° and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		901	884–917	8
Altitude (m)		42	24–65	8
Slope (degrees)		2	1–3	8
Terrain class				
North	0			0
Intermediate	0			0
South	13			1
Flat	88			7
Parent material				
Low quartz sedimentaries	13			1
Tertiary Alluvium	88			7



Map 55. Distribution of samples of Coastal Heath (Map Unit 55) shown by large black squares. Samples of other map units shown as small grey points.

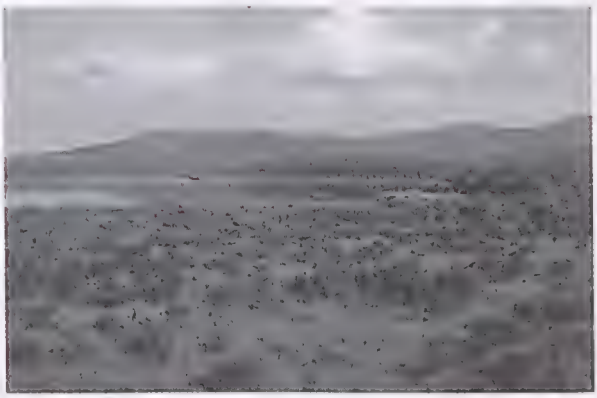


Plate 55. Coastal Heath (Map Unit 55) dominated by *Allocasuarina paludosa, Banksia paludosa* and *Epacris impressa* on Nadgee Moor in Nadgee Nature Reserve.

Map Unit 56: Hinterland Heath

Hinterland Heath has an open shrub canopy dominated by *Allocasuarina paludosa* and *Leptospermum continentale* up to 2 m tall, with *Epacris impressa* and occasionally *Callistemon citrinus*. Scattered emergent trees include *Eucalyptus ignorabilis, E. conspicua* or *E. globoidea*. The relatively dense groundcover is dominated by sedges *Empodisma minus* and *Gahnia radula*, with grasses *Poa meionectes*, herbs *Gonocarpus tetragynus*,

Goodenia paniculata, Hypericum gramineum and *Patersonia fragilis* and small ferns *Lindsaea linearis*. Hinterland Heath is restricted to small soaks in the southern granitoid hinterland, typically at 150–500 m elevation, but reaching 650 m in the Myanba Creek area. This assemblage lacks many of the shrub and forb species characteristic of the more coastal heath assemblages (Map Units 54 and 55). The most similar assemblage in East Gippsland is a lowland clay heathland entity (within Ecological Vegetation Class 7, Woodgate et al. 1994), which, like Hinterland Heath, is locally restricted but scattered widely in the hinterland. Although almost all of this restricted unit occurs on public land, a small portion is reserved and most occurs within production forest. The principal threats entail small scale clearing, earthworks, erosion, sedimentation and burning associated with logging and roading, even though the paucity of merchantable timber generally precludes direct logging of this assemblage. Frequent fire regimes may reduce diversity by interrupting life-cycle processes of woody species (Keith 1996). Intervals between planned and unplanned fires need to be long enough to allow replenishment of seed banks and restoration of habitat structure to avoid losses of diversity.

Species richness: 29 ± 4 (0.04 ha)

Extant area: 385 ha

Proportion cleared: 0%

Number of samples: 5

Table 56a. Diagnostic plant species of Map Unit 56.

Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Acacia brownii	0.2	2(2–2)	0	0(0–0)	positive
Allocasuarina paludosa	1	4(3–5)	0.015	2.5(1–4)	positive
Amphipogon strictus	0.2	2(2–2)	0	0(0–0)	positive
Empodisma minus	0.6	2(1–3)	0.012	2(1–3)	positive
Epacris impressa	0.6	2(1–2)	0.195	2(1–2)	positive
Eucalyptus ignorabilis	0.2	3(3–3)	0	0(0–0)	positive
Gahnia radula	0.6	2(2–3)	0.089	2(1–3)	positive
Gonocarpus tetragynus	0.6	2(1–2)	0.164	2(1–2)	positive
Goodenia humilis	0.2	1(1–1)	0	0(0–0)	positive
Goodenia paniculata	0.4	1(1–1)	0	0(0–0)	positive
Hypericum gramineum	0.6	2(1–2)	0.241	1(1–2)	positive
Leptospermum continentale	1	3(2–3)	0.055	1(1–2)	positive
Patersonia fragilis	0.6	2(2–3)	0.004	1(1–1)	positive
Schoenus lepidosperma subsp. *lepidosperma*	0.2	3(3–3)	0	0(0–0)	positive
Drosera peltata	0.6	1(1–2)	0.008	1(1–1)	frequent
Lindsaea linearis	1	1(1–2)	0.029	1(1–2)	frequent
Poa meionectes	0.6	1(1–3)	0.539	2(1–3)	frequent
Eucalyptus angophoroides	0.2	2(2–2)	0.044	2(1–3)	uninformative
Eucalyptus consideniana	0.2	2(2–2)	0.02	2(1–3)	uninformative
Eucalyptus conspicua	0.2	2(2–2)	0.001	2(1–3)	uninformative
Eucalyptus globoidea	0.4	1(1–1)	0.242	3(1–3)	uninformative
Eucalyptus ovata	0.2	2(2–2)	0.022	3(1–3)	uninformative
Eucalyptus radiata	0.2	1(1–1)	0.076	3(1–3)	uninformative
Eucalyptus sp. aff. *radiata*	0.2	1(1–1)	0.035	3(2–3)	uninformative
Eucalyptus viminalis	0.2	1(1–1)	0.057	3(1–3)	uninformative
Lomandra longifolia	0.2	1(1–1)	0.55	2(1–2)	negative
Pteridium esculentum	0	0(1–0)	0.579	2(1–3)	negative

Table 56b. Vegetation structure of Map Unit 56. Frequency is the proportion of samples in which strata were present. Height and cover data are means with standard errors in parentheses (n=3).

Stratum	Frequency (%)	Height (m)	Cover (%)
Tree	0	-(-)	-(-)
Small tree	66.7	5.5(0.5)	4(3)
Shrub	100	3.2(0.4)	63(12)
Ground cover	100	0.6(0.2)	65(16)

Table 56c. Habitat characteristics of Map Unit 56. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5° and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		965	958–999	5
Altitude (m)		447	330–560	5
Slope (degrees)		4	4–5	5
Terrain class				
North	40			2
Intermediate	0			0
South	0			0
Flat	60			3
Parent material				
Devonian granitoids	100			5

Map 56. Distribution of samples of Hinterland Heath (Map Unit 56) shown by large black squares. Samples of other map units shown as small grey points.

Plate 56. Hinterland Heath (Map Unit 56) variant dominated by *Callistemon paludosus, Kunzea ericoides, Gahnia sieberiana* and *Allocasuarina nana* on the White Rock River track, Genoa section of the South East Forests National Park.

Map Unit 57: Lowland Swamp

Lowland Swamp has a dense but variable shrub stratum up to 2 m tall, dominated by *Melaleuca squarrosa,* and *Leptospermum continentale* with *Callistemon citrinus, Epacris paludosa* and *Sprengelia incarnata.* Scattered emergent trees of *Eucalyptus consideniana, E. ovata* and *E. conspicua* occur mainly around the edges of swamps. The tall dense groundcover is dominated by sedges *Gahnia sieberiana, G. radula, Lepidosperma limicola, Leptocarpus tenax* and *Lomandra glauca,* with grasses *Tetrarrhena* spp., and small ferns

Selaginella uliginosa. Lowland Swamp is restricted to waterlogged soils on Tertiary alluvium, sandy colluvial granitoid soils and Holocene sands below 100 m elevation in broad open flat gullies in the Nadgee area and lower Wallagaraugh River catchment. A similar assemblage occurs within the riparian scrub complex (Ecological Vegetation Class 17, Woodgate et al. 1994) in similar lowland habitats east of Orbost in East Gippsland. Lowland Swamp includes some stands (e.g. around Nadgee Lake) with affinities to coastal lagoon wetlands (Ecological Vegetation Class 11, Woodgate et al. 1994) in East Gippsland. A relatively small area of Lowland Swamp has been cleared and about two-thirds is represented in reserves. Outside reserves, the principal threat is sedimentation from roading, burning and logging activities within swamp catchments. Frequent fires used in hazard reduction may reduce diversity by interrupting life-cycle processes of woody species. Long fire-free intervals also potentially threaten diversity of small shrubs and forbs which may be excluded by competition from the dense sedge stratum (Keith 1996). Thus to maintain diversity, intervals between planned and unplanned fires need to be long enough to allow replenishment of seed banks and restoration of habitat structure, and shorter than the combined longevity of standing plants and seed banks.

Species richness: 28 ± 4 (0.04 ha)

Extant area: 1582 ha

Proportion cleared: 2%

Number of samples: 9

Table 57a. Diagnostic plant species of Map Unit 57.

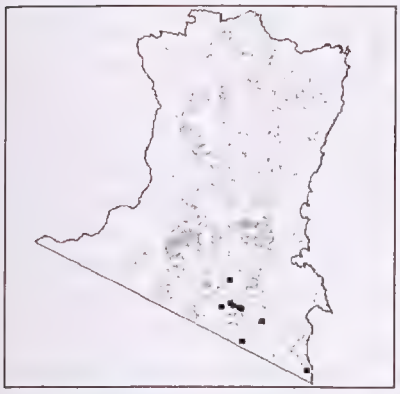
Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Baumea teretifolia	0.222	1.5(1–2)	0	0(0–0)	positive
Boronia parviflora	0.333	1(1–1)	0	0(0–0)	positive
Callistemon citrinus	0.667	3(1–3)	0.004	2.5(1–3)	positive
Comesperma retusum	0.111	2(2–2)	0	0(0–0)	positive
Drosera binata	0.111	1(1–1)	0	0(0–0)	positive
Empodisma minus	1	2(2–4)	0.008	2(1–3)	positive
Epacris paludosa	0.556	2(2–3)	0.005	2(1–4)	positive
Gahnia radula	0.556	3(2–4)	0.088	2(1–3)	positive
Gahnia sieberiana	0.556	2(2–3)	0.074	1(1–2)	positive
Lepidosperma limicola	0.556	3(2–4)	0.002	1(1–3)	positive
Leptocarpus tenax	0.778	3(2–3)	0.003	3(2–5)	positive
Leptospermum continentale	0.889	2.5(2–3)	0.053	1(1–2)	positive
Melaleuca squarrosa	1	4(3–4)	0.006	2(2–3)	positive
Sowerbaea juncea	0.111	1(1–1)	0	0(0–0)	positive
Sprengelia incarnata	0.667	2(2–3)	0.001	2(1–3)	positive
Tetrarrhena juncea	0.556	2(2–3)	0.18	2(1–3)	positive
Tetrarrhena turfosa	0.111	2(2–2)	0	0(0–0)	positive
Villarsia exaltata	0.111	1(1–1)	0	0(0–0)	positive
Viminaria juncea	0.111	1(1–1)	0	0(0–0)	positive
Selaginella uliginosa	0.778	1(1–2)	0.007	2(1–3)	frequent
Eucalyptus agglomerata	0.111	1(1–1)	0.109	3(2–3)	uninformative
Eucalyptus angophoroides	0.111	1(1–1)	0.044	2(1–3)	uninformative
Eucalyptus consideniana	0.444	1(1–1)	0.018	3(2–3)	uninformative
Eucalyptus conspicua	0.111	1(1–1)	0.001	2.5(2–3)	uninformative
Eucalyptus ovata	0.222	1(1–1)	0.022	3(1–3)	uninformative
Lomandra longifolia	0.333	1(1–3)	0.55	2(1–2)	negative
Poa meionectes	0.111	1(1–1)	0.541	2(1–3)	negative
Pteridium esculentum	0	0(1–0)	0.58	2(1–3)	negative

Table 57b. Vegetation structure of Map Unit 57. Frequency is the proportion of samples in which strata were present. Height and cover data are means with standard errors in parentheses (n=9).

Stratum	Frequency (%)	Height (m)	Cover (%)
Tree	0	-(-)	-(-)
Small tree	55.6	9(0.5)	2(1)
Shrub	100	1.8(0.1)	52(7)
Ground cover	100	1.2(0.1)	91(4)

Table 57c. Habitat characteristics of Map Unit 57. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5° and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		910	869–927	9
Altitude (m)		179	70–250	9
Slope (degrees)		3	2–4	9
Terrain class				
North	0			0
Intermediate	22			2
South	0			0
Flat	78			7
Parent material				
Devonian granitoids	67			6
Holocene Riverine Alluvuim	11			1
Tertiary Alluvium	22			2



Map 57. Distribution of samples of Lowland Swamp (Map Unit 57) shown by large black squares. Samples of other map units shown as small grey points.

Plate 57. Lowland Swamp (Map Unit 57) dominated by *Melaleuca squarrosa, Epacris paludosa, Sprengelia incarnata* and sedges on Timbillica Road in Sidlings Swamp Flora Reserve. *Eucalyptus cephalocarpa* occurs on the swamp edge in background.

Map Unit 58: Swamp Forest

Swamp Forest is dominated by *Eucalyptus ovata,* sometimes with *E. viminalis* c. 20 m tall. The shrub stratum is very sparse and includes scattered *Acacia melanoxylon,* sometimes reaching the size of small trees to 8 m tall, with *Olearia glandulosa.* The continuous groundcover is dominated by grasses and graminoids *Carex appressa,*

C. gaudichaudiana, Cyperus lucidus, Eleocharis gracilis, Juncus spp., *Poa labillardieri* and *Lomandra longifolia*, with interstitial herbs including *Geranium solanderi, Hydrocotyle peduncularis* and *Gratiola peruviana*. Swamp Forest is restricted to deep waterlogged colluvial flats derived from surrounding granitoid slopes. Standing water and peat may occur at limited locations. It occurs within an elevational range of 300–650 m in the southern granitoid hinterland and has some floristic affinities with swampy riparian forest within the riparian scrub complex of East Gippsland (Ecological Vegetation Class 17, Woodgate et al. 1994), most notably in the overstorey, although few of the major understorey species are held in common. About 10% of Swamp Forest has been cleared, the remainder occurring in reserves and State Forest. Outside reserves, the principal threat is sedimentation from roading, burning and logging activities within swamp forest catchments, particularly in the largest stand at Snob Creek. Very intense fires may consume peat at sites where this has developed. Frequent fires used in hazard reduction may reduce diversity by interrupting life-cycle processes of woody species. If very frequent, they may maintain the groundcover in a more open state that is less suitable as shelter for some ground fauna. Thus to maintain diversity, intervals between planned and unplanned fires need to be long enough to allow replenishment of seed banks and restoration of habitat structure.

Species richness: 30 ± 4 (0.04 ha)

Extant area: 1056 ha

Proportion cleared: 11%

Number of samples: 14

Table 58a. Diagnostic plant species of Map Unit 58.

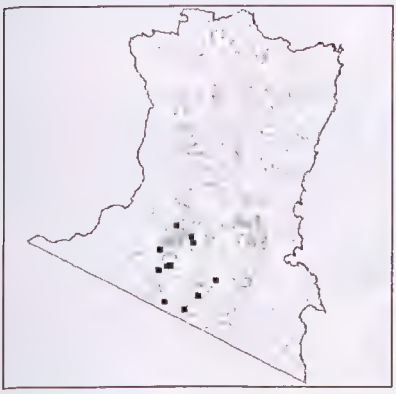
Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Carex appressa	0.5	3(1–4)	0.08	1(1–2)	positive
Carex gaudichaudiana	0.571	3(2–5)	0.005	1(1–2)	positive
Cyperus lucidus	0.5	3(1–3)	0.011	2(1–2)	positive
Eleocharis gracilis	0.5	2(1–3)	0.003	2(1–3)	positive
Eucalyptus ovata	0.786	3(2–3)	0.016	2(1–3)	positive
Geranium neglectum	0.571	2(1–2)	0.005	1(1–1)	positive
Hydrocotyle peduncularis	0.643	2(1–2)	0.01	1(1–2)	positive
Juncus homalocaulis	0.071	1(1–1)	0	0(0–0)	positive
Juncus sarophorus	0.357	2(2–3)	0	0(0–0)	positive
Olearia glandulosa	0.143	2(1–3)	0	0(0–0)	positive
Poa labillardieri var. *labillardieri*	0.643	3(3–4)	0.165	1(1–2)	positive
Potamogeton tricarinatus	0.071	1(1–1)	0	0(0–0)	positive
Ranunculus amphitrichus	0.071	1(1–1)	0	0(0–0)	positive
Stellaria angustifolia	0.143	1.5(1–2)	0	0(0–0)	positive
Lomandra longifolia	0.929	3(2–5)	0.545	2(1–2)	frequent
Gratiola peruviana	0.929	1(1–2)	0.015	1.5(1–2)	frequent
Acacia melanoxylon	0.429	1.5(1–2)	0.102	1(1–3)	uninformative
Eucalyptus cypellocarpa	0.071	2(2–2)	0.316	3(2–3)	uninformative
Eucalyptus globoidea	0.143	1(1–1)	0.244	3(1–3)	uninformative
Eucalyptus radiata	0.071	1(1–1)	0.077	3(1–3)	uninformative
Eucalyptus sieberi	0.071	1(1–1)	0.285	3(2–4)	uninformative
Eucalyptus sp. aff. *radiata*	0.071	1(1–1)	0.035	3(2–3)	uninformative
Eucalyptus viminalis	0.286	3(2–4)	0.055	3(1–3)	uninformative
Poa meionectes	0.143	2(2–2)	0.543	2(1–3)	negative
Pteridium esculentum	0.214	1(1–2)	0.58	2(1–3)	negative

Table 58b. Vegetation structure of Map Unit 58. Frequency is the proportion of samples in which strata were present. Height and cover data are means with standard errors in parentheses (n=8).

Stratum	Frequency (%)	Height (m)	Cover (%)
Tree	75	20.8(3.6)	28(7)
Small tree	12.5	8.0(-)	4(-)
Shrub	87.5	1.7(0.1)	25(9)
Ground cover	100	0.6(0.1)	81(9)

Table 58c. Habitat characteristics of Map Unit 58. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5° and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		982	964–997	14
Altitude (m)		487	399–530	14
Slope (degrees)		2	0–3	14
Terrain class				
North	14			2
Intermediate	0			0
South	0			0
Flat	86			12
Parent material				
Devonian granitoids	93			13
Holocene Riverine Alluvuim	7			1



Map 58. Distribution of samples of Swamp Forest (Map Unit 58) shown by large black squares. Samples of other map units shown as small grey points.

Plate 58. Swamp Forest (Map Unit 58) dominated by *Eucalyptus ovata* and *E. viminalis* with scattered *Acacia melanoxylon* and a continuous groundcover of *Poa labillardieri, Lomandra longifolia* and *Carex* spp. at Sheep Station Creek, Genoa section of South East Forests National Park.

Map Unit 59: Subalpine Bog

Subalpine Bog has an open shrub stratum over 1 m tall dominated by *Baeckea utilis, Epacris paludosa, Hakea microcarpa* and numerous less frequent species in the Myrtaceae and Epacridaceae. Scattered emergent trees including *Eucalyptus pauciflora* and *E. parvula* occur mainly around the edges of swamps. The continuous groundcover is dominated by sedges *Baloskion australe, Lepyrodia anarthria* and *Empodisma minus*, with

grasses (e.g. *Agrostis* 'hiemalis'), and a diverse range of herbs *Asperula gunnii, Hydrocotyle peduncularis, Pratia surrepens* and *Gonocarpus micranthus*. Subalpine Bog is restricted to waterlogged broad open flat gullies on alluvium derived from granitoid substrates or metasediments above 800 m elevation on the edge of the Monaro Tableland. Perennial and ephemeral lakes have developed in basalt depressions on the tableland, although most of these are located to the west of the study area. Their flora and vegetation is described by Benson & Jacobs (1994). There is usually development of substantial peat, and standing water is common in winter. A similar assemblage extends further north along the edge of the Monaro Tableland and also south into East Gippsland (Community 1.2, Forbes et al. 1982). Almost 72% of this unit has been cleared or heavily degraded by grazing and over half of the remainder occurs on private land where it is subject to further clearing, continuing degradation by trampling, grazing, nutrification, sedimentation and weed invasion associated with pastoral land uses. The spongy peat soils are especially vulnerable to trampling by stock, which must therefore be excluded if degradation is to be minimised. Bogs in state forest may be affected by sedimentation and burning in adjacent forest, but to a lesser extent than those in pastoral areas. Some stands may also be threatened by peat mining, as has occurred at Killarney Swamp near Bombala. Frequent fires used in hazard reduction and grazing management may reduce diversity by interrupting life-cycle processes of woody species. Intense fires may consume peat, changing habitat structure of the bogs for many years (Keith 1996). Thus intervals between planned and unplanned fires need to be long enough to allow replenishment of seed banks and restoration of habitat structure, and very intense fires need to be excluded if losses of diversity are to be avoided.

Species richness: 29 ± 4 (0.04 ha)
Extant area: 1897 ha
Proportion cleared: 77%
Number of samples: 9

Table 59a. Diagnostic plant species of Map Unit 59.

Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Agrostis 'hiemalis'	0.143	1(1–1)	0	0(0–0)	positive
Almaleea subumbellata	0.143	1(1–1)	0	0(0–0)	positive
Asperula gunnii	0.571	2(1–2)	0.018	1(1–1)	positive
Baeckea gunniana	0.143	4(4–4)	0	0(0–0)	positive
Baeckea utilis	0.571	3(2–3)	0.002	1(1–1)	positive
Baloskion australe	0.857	2.5(1–3)	0.001	1(1–1)	positive
Boronia deanei	0.143	4(4–4)	0	0(0–0)	positive
Callistemon pityoides	0.143	3(3–3)	0	0(0–0)	positive
Carex capillacea	0.143	1(1–1)	0	0(0–0)	positive
Celmisia 'pulchella' ms	0.143	2(2–2)	0	0(0–0)	positive
Cotula alpina	0.143	1(1–1)	0	0(0–0)	positive
Notodanthonia eriantha	0.143	1(1–1)	0	0(0–0)	positive
Empodisma minus	0.571	3(2–4)	0.012	2(1–3)	positive
Epacris breviflora	0.286	1(1–1)	0	0(0–0)	positive
Epacris paludosa	0.571	3.5(2–4)	0.005	2(1–3)	positive
Epacris petrophila	0.143	3(3–3)	0	0(0–0)	positive
Festuca hookeriana	0.143	1(1–1)	0	0(0–0)	positive
Hydrocotyle algida	0.143	1(1–1)	0	0(0–0)	positive

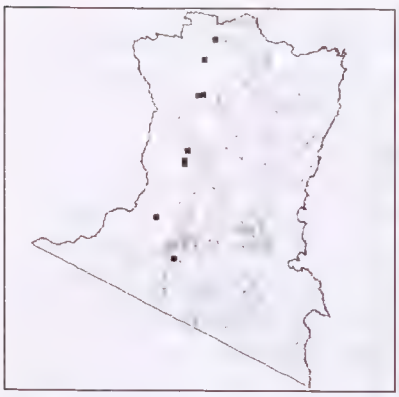
Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Hydrocotyle peduncularis	0.571	2(1–3)	0.013	1(1–2)	positive
Isolepis aucklandica	0.143	1(1–1)	0	0(0–0)	positive
Juncus phaeanthus	0.143	1(1–1)	0	0(0–0)	positive
Lepyrodia anarthria	0.571	3(2–3)	0.003	2(1–4)	positive
Nertera granadensis	0.143	1(1–1)	0	0(0–0)	positive
Poa costiniana	0.143	1(1–1)	0	0(0–0)	positive
Pratia surrepens	0.429	1(1–2)	0	0(0–0)	positive
Trisetum spicatum	0.143	1(1–1)	0	0(0–0)	positive
Velleia montana	0.143	1(1–1)	0	0(0–0)	positive
Viola caleyana	0.143	1(1–1)	0	0(0–0)	positive
Gonocarpus micranthus	0.714	1(1–2)	0.01	1(1–1)	frequent
Hakea microcarpa	0.857	1(1–3)	0.001	1(1–1)	frequent
Eucalyptus pauciflora	0.429	1(1–3)	0.021	2(1–3)	uninformative
Eucalyptus rubida	0.143	1(1–1)	0.006	1(1–3)	uninformative
Eucalyptus viminalis	0.143	1(1–1)	0.057	3(1–3)	uninformative
Lomandra longifolia	0	0(1–0)	0.552	2(1–2)	negative
Poa meionectes	0.286	2(2–2)	0.54	2(1–3)	negative
Pteridium esculentum	0	0(1–0)	0.58	2(1–3)	negative

Table 59b. Vegetation structure of Map Unit 59. Frequency is the proportion of samples in which strata were present. Height and cover data are means with standard errors in parentheses (n=5).

Stratum	Frequency (%)	Height (m)	Cover (%)
Tree	0	-(-)	-(-)
Small tree	40	9.8(2.3)	27(23)
Shrub	100	1.2(0.3)	53(12)
Ground cover	100	0.4(0.1)	69(12)

Table 59c. Habitat characteristics of Map Unit 59. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5° and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		923	857–930	9
Altitude (m)		974	938–1036	8
Slope (degrees)		2	1–2	8
Terrain class				
North	13			1
Intermediate	0			0
South	0			0
Flat	88			7
Parent material				
Devonian granitoids	67			6
Devonian high quartz sedimentaries	11			1
Holocene Riverine Alluvuim	11			1
Ordovician high quartz sedimentaries	11			1



Map 59. Distribution of samples of Subalpine Bog (Map Unit 59) shown by large black squares. Samples of other map units shown as small grey points.

Plate 59. Subalpine Bog (Map Unit 59) dominated by *Baeckea utilis, Hakea microcarpa, Epacris breviflora,* and *Baloskion australe* with *Pratia surrepens* along the drainage line at Nunnock Swamp, Tantawangalo section of South East Forests National Park.

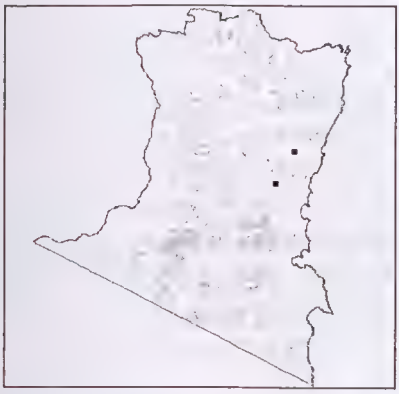
Map Unit 60: Floodplain Wetlands

Floodplain Wetlands is a complex of plant assemblages including reedlands, herbfields, scrubs and swamp forests. Only the latter were sampled quantitatively. Herbaceous wetlands are dominated by *Phragmites australis, Eleocharis sphacelata* and *Typha* spp. and typically have standing water for much of the year. The wooded floodplain swamp forests are dominated by scattered *Eucalyptus ovata,* and may have patchy thickets of *Melaleuca ericifolia* with *Hymenanthera dentata.* The diverse groundcover is patchy and poorly developed beneath dense patches of shrubs. It includes herbs *Callitriche muelleri, Persicaria decipiens, Centella asiatica, Dichondra repens, Geranium solanderi, Lagenifera stipitata, Lobelia alata, Pratia purpurascens, Rumex brownii* and *Senecio minimus,* sedges *Carex* spp., *Eleochaeris acuta, Isolepis habra* and *Juncus planifolius,* and ferns *Adiantum aethiopicum, Blechnum minus* and *Pteris tremula.* Remnants of forested wetlands occur around the margins of the floodplains. Floodplain Wetlands are restricted to the floodplains of the lower Bega and Towamba Rivers on riverine alluvium. Two-thirds of Floodplain Wetlands have been cleared for agriculture and coastal development, while three-quarters of the remainder occur on private land where they are threatened by further clearing, nutrification, weed invasion, trampling and grazing. Much of the remaining area, including that on public land, is wooded wetland. Some herbaceous wetlands persist in varying states of degradation near the town of Bega and at Jellat Jellat. Floodplain vegetation on Australia's south-east coast is generally depleted by clearing and degraded by grazing and weed invasion (e.g. Pressey 1989). In East Gippsland the most similar assemblage is restricted to areas adjacent to coastal lagoons (Ecological Vegetation Type 11, Woodgate et al. 1994).

Species richness: 39 ± 7 (0.04 ha)
Extant area: 2774 ha
Proportion cleared: 68%
Number of samples: 3

Table 60a. Diagnostic plant species of Map Unit 60.

Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Blechnum minus	0.667	2(1–3)	0.01	1(1–1)	positive
Callitriche muelleri	0.667	2(1–3)	0	0(0–0)	positive
Carex appressa	0.667	2(1–3)	0.083	1(1–2)	positive
Carex brownii	0.333	1(1–1)	0	0(0–0)	positive
Carex longebrachiata	0.667	2.5(2–3)	0.035	1(1–2)	positive
Eleocharis acuta	0.333	2(2–2)	0	0(0–0)	positive
Eucalyptus ovata	0.667	2(1–3)	0.022	3(1–3)	positive
Gahnia clarkei	0.333	1(1–1)	0	0(0–0)	positive
Gratiola pedunculata	0.333	1(1–1)	0	0(0–0)	positive
Hymenanthera dentata	1	2(1–3)	0.068	1(1–2)	positive
Isolepis habra	0.667	2(2–2)	0.01	1(1–2)	positive
Melaleuca ericifolia	1	5(4–6)	0.004	3.5(3–6)	positive
Microlaena stipoides var. *stipoides*	0.667	2.5(2–3)	0.353	2(1–2)	positive
Oplismenus imbecillis	0.667	2(2–2)	0.108	2(1–2)	positive
Persicaria decipiens	0.667	2(2–2)	0.004	1(1–1)	positive
Acaena novae–zelandiae	0.667	1(1–1)	0.131	1(1–2)	frequent
Adiantum aethiopicum	0.667	1.5(1–2)	0.076	1(1–2)	frequent
Cassytha phaeolasia	0.667	1(1–1)	0.044	1(1–2)	frequent
Centella asiatica	0.667	1(1–1)	0.005	1(1–2)	frequent
Coprosma quadrifida	0.667	1(1–1)	0.245	1(1–2)	frequent
Dichondra repens	1	1(1–2)	0.283	2(1–2)	frequent
Entolasia marginata	0.667	1(1–1)	0.045	1(1–2)	frequent
Geranium solanderi	1	1(1–1)	0.091	1(1–2)	frequent
Juncus planifolius	1	1(1–1)	0.014	1(1–1)	frequent
Lagenifera stipitata	1	1(1–2)	0.323	1(1–2)	frequent
Lobelia alata	1	1(1–1)	0.007	1(1–1)	frequent
Pratia purpurascens	1	1(1–2)	0.101	1(1–2)	frequent
Pteris tremula	0.667	1.5(1–2)	0.008	1(1–1)	frequent
Ranunculus plebeius	0.667	1.5(1–2)	0.059	1(1–2)	frequent
Rubus parvifolius	0.667	1(1–1)	0.139	1(1–2)	frequent



Map 60. Distribution of samples of Floodplain Wetland (Map Unit 60) shown by large black squares. Samples of other map units shown as small grey points.

Plate 60. Remnant Floodplain Wetland (Map Unit 60) dominated by *Phragmites australis* with scattered *Melaleuca ericifolia* at Whelans Swamp on Princes Highway south of Eden.

Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Rumex brownii	1	1(1–1)	0.054	1(1–1)	frequent
Senecio minimus	1	1(1–1)	0.022	1(1–1)	frequent
Viola hederacea subsp. *hederacea*	0.667	1.5(1–2)	0.437	2(1–2)	frequent
Lomandra longifolia	0.333	1(1–1)	0.549	2(1–2)	negative
Poa meionectes	0	0(1–0)	0.54	2(1–3)	negative
Pteridium esculentum	0	0(1–0)	0.578	2(1–3)	negative

Table 60b. Vegetation structure of Map Unit 60. Frequency is the proportion of samples in which strata were present. Height and cover data are means with standard errors in parentheses (n=3).

Stratum	Frequency	Height (m)	Cover (%)
Tree	67	12.5(2.5)	12(9)
Small tree	100	7.0(0.6)	63(9)
Shrub	100	2.7(0.3)	17(7)
Ground cover	100	0.3(0.1)	23(7)

Table 60c. Habitat characteristics of Map Unit 60. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5° and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		814	812–819	3
Altitude (m)		53	15–75	3
Slope (degrees)		1	0–1	3
Terrain class				
North	0			0
Intermediate	0			0
South	0			0
Flat	100			3
Parent material				
Holocene Riverine Alluvuim	100			3

Map Unit 61: Coastal Scrub

Coastal Scrub has a variable shrub stratum up to 3 m tall, dominated by *Acacia sophorae, Banksia integrifolia* and *Leucopogon parviflorus*. These species occur with high frequency, but there are numerous less frequent species apparently exclusive to this assemblage. *Eucalyptus botryoides* is an occasionally emergent small tree. The patchy groundcover includes the prostrate succulent herb *Carpobrotus glaucescens*, the sedge *Isolepis nodosa* and the herb *Oxalis perennans*. Coastal Scrub is restricted to foredunes and headlands immediately adjacent to the coast. Although assemblages growing in these two habitats are recognisably different in composition and structure, they are presently mapped together. On foredunes, the shrub stratum is shorter and more open and includes a more diverse range of species, several of which are rarely seen on rocky substrates (e.g. *Alyxia buxifolia, Leucopogon parviflorus*). On rocky headlands, tall thickets are dominated by *Melaleuca armillaris* and *Allocasuarina verticellata*, which rarely occur on sand dunes. Some species, such as *Banksia integrifolia*, are ubiquitous in both habitats. Dune Dry Shrub Forest (Map Unit 36) may be adjacent to Coastal Scrub in more sheltered sites on sand dunes. Beach Strand Grassland (Map Unit 62) occurs

between Coastal Scrub and the high tide mark. Due to the small size of Beach Strand patches, these two assemblages are mapped together. Similar assemblages extend both north and south of the Eden region. In East Gippsland *Leptospermum laevigatum* becomes a dominant shrub species (Community 20, Forbes et al. 1982; Ecological Vegetation Class 1, Woodgate et al. 1994). One-third of Coastal Scrub has been cleared for coastal development. Although most of the remainder is represented within reserves, some of these reserved areas and some off-reserve sites are threatened by intense recreational usage and development pressures. Causes of continuing degradation include rubbish dumping, small-scale clearing and burning, firewood harvesting, trampling and weed invasion.

Species richness: 17 ± 1 (0.04 ha)
Extant area: 1358 ha (includes a small area of Beach Strand, Map Unit 62)
Proportion cleared: 33%
Number of samples: 41

Table 61a. Diagnostic plant species of Map Unit 61.

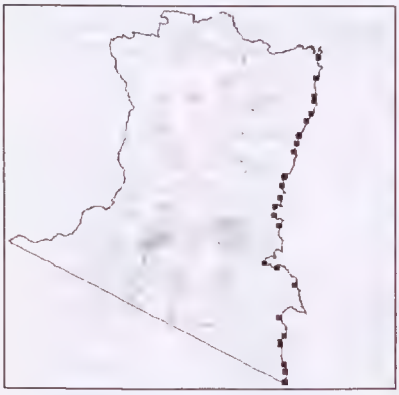
Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Allocasuarina verticillata	0.024	3(3–3)	0	0(0–0)	positive
Alyxia buxifolia	0.122	1(1–2)	0	0(0–0)	positive
Apalochlamys spectabilis	0.024	1(1–1)	0	0(0–0)	positive
Clematis microphylla var. *leptophylla*	0.098	1(1–1)	0	0(0–0)	positive
Correa alba	0.049	2(1–3)	0	0(0–0)	positive
Kunzea capitata	0.024	1(1–1)	0	0(0–0)	positive
Solanum stelligerum	0.024	1(1–1)	0	0(0–0)	positive
Acacia sophorae	0.927	1(1–2)	0.009	1(1–1)	frequent
Banksia integrifolia	0.854	1(1–2)	0.012	1(1–2)	frequent
Carpobrotus glaucescens	0.683	1(1–1)	0.011	1(1–1)	frequent
Isolepis nodosa	0.683	1(1–1)	0.01	1(1–2)	frequent
Leucopogon parviflorus	0.634	1(1–1)	0.002	1(1–1)	frequent
Oxalis perennans	0.683	1(1–1)	0.209	1(1–1)	frequent
Pteridium esculentum	0.561	1(1–1)	0.577	2(1–3)	frequent
Eucalyptus botryoides	0.024	1(1–1)	0.011	2(1–3)	uninformative
Eucalyptus longifolia	0.024	2(2–2)	0.03	3(2–3)	uninformative
Eucalyptus sieberi	0.024	1(1–1)	0.29	3(2–4)	uninformative
Eucalyptus tereticornis	0.024	1(1–1)	0.048	3(1–3)	uninformative
Lomandra longifolia	0.366	1(1–1)	0.554	2(1–2)	negative
Poa meionectes	0.195	1(1–1)	0.549	2(1–3)	negative

Table 61b. Vegetation structure of Map Unit 61. Frequency is the proportion of samples in which strata were present. Height and cover data are means with standard errors in parentheses (n=5).

Stratum	Frequency (%)	Height (m)	Cover (%)
Tree	60	9.7(0.9)	50(26)
Small tree	0	-(-)	-(-)
Shrub	100	2.7(0.5)	51(15)
Ground cover	100	0.7(0.2)	38(18)

Table 61c. Habitat characteristics of Map Unit 61. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5° and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		813	838–897	41
Altitude (m)		5	5–5	41
Slope (degrees)		9	5–11	5
Terrain class				
North	0			0
Intermediate	80			4
South	0			0
Flat	20			1
Parent material				
Holocene Coastal Sands	98			40
Low quartz sedimentaries	2			1



Map 61. Distribution of samples of Coastal Scrub (Map Unit 61) shown by large black squares. Samples of other map units shown as small grey points.

Plate 61. Coastal Scrub (Map Unit 61) dune variant with *Banksia integrifolia, Acacia sophorae, Westringia fruticosa, Leucopogon parviflorus, Isolepis nodosa* and *Lomandra longifolia* on the foredune at Picnic Point, northern section of Mimosa Rocks National Park. Headland variant dominated by *Allocasuarina verticellata* in background.

Map Unit 62: Beach Strand Grassland

Beach Strand Grassland has a sparse ground stratum dominated by grasses *Spinifex sericeus* and *Festuca littoralis*, with scattered patches of the prostrate succulent herb *Carpobrotus glaucescens*. Beach Strand Grassland is restricted to mobile, unconsolidated calcareous sands on beach strands directly above the high tide mark on the seaward side of Coastal Scrub (Map Unit 61) on beach foredunes. Individual occurrences are generally linear in shape and less than 20 m wide. Coastal Scrub and Beach Strand Grassland (Map Units 61 and 62) were therefore mapped together as a mosaic. Similar assemblages extend both north and south of the Eden region. In East Gippsland similar vegetation is included within the coastal dune scrub complex (Community 20, Forbes et al. 1982; Ecological Vegetation Class 1, Woodgate et al. 1994). Beach Strand Grassland is a very resilient, species-poor assemblage. Its principal species tolerate a wide range of physical disturbances and are widely dispersed by wind and wave

action. There are numerous beaches represented in reserves. Beach strands subject to intense recreational usage have grassland with reduced density due to trampling. Some stands include maritime weeds such as *Cakile edentula*.

Species richness: 5 ± 1 (0.04 ha)

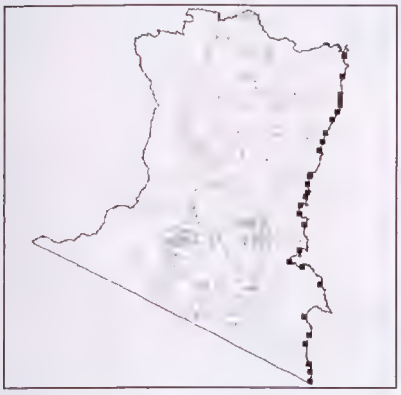
Extant area: 100 ha (approximation only, mapped in mosaic with Map Unit 61)

Proportion cleared: < 10% (approximation only, mapped in mosaic with Map Unit 61)

Number of samples: 30

Table 62a. Diagnostic plant species of Map Unit 62.

Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Agrostis billardieri	0.067	1(1–1)	0	0(0–0)	positive
Apium prostratum var. *prostratum*	0.067	1(1–1)	0	0(0–0)	positive
Festuca littoralis	0.667	1(1–1)	0.003	1(1–1)	frequent
Spinifex sericeus	1	1(1–2)	0.011	1(1–1)	frequent
Carpobrotus glaucescens	0.533	1(1–1)	0.019	1(1–1)	uninformative
Lomandra longifolia	0.033	1(1–1)	0.56	2(1–2)	negative
Poa meionectes	0	0(3–0)	0.55	2(1–3)	negative
Pteridium esculentum	0	0(2–0)	0.589	2(1–3)	negative



Map 62. Distribution of samples of Beach Strand Grassland (Map Unit 62) shown by large black squares. Samples of other map units shown as small grey points.

Plate 62. Beach Strand Grassland (Map Unit 62) dominated by *Spinifex sericeus* and *Festuca littoralis* with Coastal Scrub on adjacent foredune of Gillards Beach, southern section of Mimosa Rocks National Park.

Table 62b. Habitat characteristics of Map Unit 62. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5° and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		726	836–883	30
Altitude (m)		2	2–2	30
Slope (degrees)		0	0–2	30
Terrain class				
North	0			30
Intermediate	0			30
South	0			30
Flat	100			30
Parent material				
Holocene Coastal Sands	100			30

Map Unit 63: Estuarine Wetland Scrub

Estuarine Wetland Scrub has a dense shrub stratum dominated by *Melaleuca ericifolia* with *Acacia floribunda, Hymenanthera dentata* and *Myoporum acuminatum*. The groundcover includes grasses and graminoids *Carex appressa, Microlaena stipoides, Echinopogon ovatus, Entolasia marginata, Isolepis nodosa, Oplismenus imbecillus* and *Phragmites australis*, and herbs *Acaena nova-zelandiae, Alternanthera denticulata, Commelina cyanea, Geranium potentilloides, Pratia purpurascens* and *Urtica incisa*. Vines *Stephania japonica* and, in the north, *Parsonsia straminea* climb amongst shrubs and sprawl over the groundcover. Estuarine Wetland Scrub is restricted to semi-saline flats on tributary creeks of coastal lagoons (e.g. Wapengo Lagoon, Merimbula Lake). Over two-thirds of this unit has been cleared and most of the remainder occurs on private land where it is threatened by further clearing and degradation through nutrification, sedimentation and weed invasion associated with adjacent urban and rural land uses. Similar assemblages extend along the coast both north and south of the Eden region. However, these occurrences are restricted. To the north, Estuarine Wetland Scrub is progressively replaced by *Casuarina glauca* fringe forest, a species that reaches its southern limit at Bermagui. In East Gippsland, for example, 'Melaleuca Scrub' is included within the estuarine wetland complex (Ecological Vegetation Class 10, Woodgate et al. 1994), a unit mapped over less than 800 ha.

Species richness: 22 ± 2 (0.04 ha)
Extant area: 956 ha
Proportion cleared: 68%
Number of samples: 4

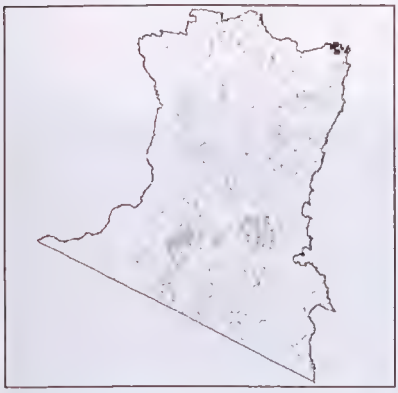
Table 63a. Diagnostic plant species of Map Unit 63.

Species	Target frequency	Target C/A	Residual frequency	Residual C/A	Fidelity class
Acacia floribunda	0.5	2(1–3)	0.016	2(1–3)	positive
Acaena novae–zelandiae	0.5	2(2–2)	0.131	1(1–2)	positive
Alternanthera denticulata	0.75	1(1–2)	0	0(0–0)	positive
Apium prostratum var. *filiforme*	0.25	3(3–3)	0	0(0–0)	positive
Carex appressa	1	2(1–2)	0.082	1(1–2)	positive
Carex longebrachiata	0.5	2(2–2)	0.035	1(1–2)	positive
Casuarina glauca	0.25	1(1–1)	0	0(0–0)	positive
Commelina cyanea	0.75	2(2–2)	0.006	1(1–1)	positive
Echinopogon ovatus	0.5	2(2–2)	0.164	1(1–2)	positive
Entolasia marginata	0.5	2(2–2)	0.045	1(1–2)	positive
Geranium potentilloides	0.5	2(2–2)	0.215	1(1–2)	positive
Hymenanthera dentata	0.5	2.5(2–3)	0.069	1(1–2)	positive
Isolepis nodosa	0.5	2(2–2)	0.027	1(1–1)	positive
Melaleuca ericifolia	0.75	4(3–6)	0.004	4.5(3–6)	positive
Microlaena stipoides var. *stipoides*	0.75	2(2–2)	0.354	2(1–2)	positive
Myoporum acuminatum	0.5	3(3–3)	0.001	1(1–1)	positive
Oplismenus imbecillis	0.75	2(2–3)	0.107	2(1–2)	positive
Parsonsia straminea	1	2(2–3)	0.003	1(1–2)	positive
Phragmites australis	0.5	2(2–2)	0.003	1(1–2)	positive
Pratia purpurascens	0.5	2(2–2)	0.102	1(1–2)	positive
Samolus repens	0.25	2(2–2)	0	0(0–0)	positive

Sarcocornia quinqueflora	0.25	2(2–2)	0	0(0–0)	positive
Senecio linearifolius	0.5	2(2–2)	0.239	1(1–2)	positive
Stephania japonica var. *discolor*	0.75	2(1–2)	0.023	1(1–2)	positive
Suaeda australis	0.25	2(2–2)	0	0(0–0)	positive
Urtica incisa	0.5	2.5(2–3)	0.068	1(1–2)	positive
Viola hederacea subsp. *hederacea*	0.5	2(2–2)	0.437	2(1–2)	positive
Lomandra longifolia	0.5	1.5(1–2)	0.549	2(1–2)	frequent
Eucalyptus bosistoana	0.5	1(1–1)	0.052	2(1–3)	uninformative
Poa meionectes	0	0(3–0)	0.54	2(1–3)	negative
Pteridium esculentum	0	0(2–0)	0.578	2(1–3)	negative

Table 63b. Habitat characteristics of Map Unit 63. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5° and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		919	918–919	4
Altitude (m)		15	10–20	4
Slope (degrees)		0	0–0	4
Terrain class				
North	0			0
Intermediate	0			0
South	0			0
Flat	100			4
Parent material				
Holocene Riverine Alluvuim	50			2
Ordovician high quartz sedimentaries	50			2



Map 63. Distribution of samples of Estuarine Wetland Scrub (Map Unit 63) shown by large black squares. Samples of other map units shown as small grey points.

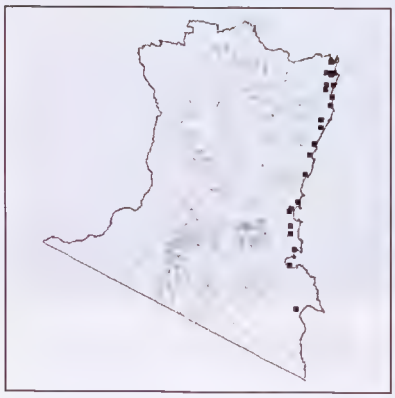
Plate 63. Estuarine Wetland Scrub (Map Unit 63) dominated by *Melaleuca ericifolia* with *Phragmites australis* in Bermagui estuary.

Map Unit 64: Saltmarsh

Saltmarsh includes a complex of floristic assemblages juxtaposed in a fine-scale mosaic. Floristic data recorded in 5 × 5 m quadrats were compiled from Clarke (unpubl.). The most ubiquitous dominant species is the succulent herb *Sarcocornia*

quinqueflora, although several other species may attain local dominance including grasses *Phragmites australis*, *Sporobolus virginicus*, *Austrostipa stipoides* and *Zoysia macrantha*, sedges *Baumea juncea* and *Juncus kraussii*, and the herb *Limonium australe*. Other frequent groundcover species include the herbs *Samolus repens*, *Selliera radicans*, *Suaeda australis* and *Wilsonia backhousei*. Scattered or clumped shrubs may emerge from the continuous groundcover, including *Sclerostegia arbuscula*, *Avicennia marina* and *Melaleuca ericifolia*. The latter two species suggest local gradation between Saltmarsh and other estuarine wetland assemblages (Map Unit 66 Grey Mangrove and Map Unit 63 Estuarine Wetland Scrub, respectively). Saltmarsh occurs on the upper limit of the inter-tidal zone on the shores of estuaries and saline lagoons scattered from Wallaga Lake to Wonboyn. The largest stands occur at Merimbula Lake and Bermagui River. Similar but locally restricted assemblages extend north and south of the Eden region. In East Gippsland, for example, Estuarine Wetland Complex (Ecological Vegetation Class 10, Woodgate et al. 1994), a unit including saltmarsh and other estuarine wetlands, is mapped over less than 800 ha. More than one-quarter of the region's Saltmarsh has been cleared for coastal development. Although a small portion of the remainder is protected in conservation reserves, a larger area is protected under NSW State Environmental Planning Policy. Nevertheless, continuing degradation associated with foreshore and catchment development, and intensifying recreational use of the coast pose significant threats to these restricted habitats.

Species richness: 4 ± 0 (0.0025 ha)
Extant area: 295 ha
Proportion cleared: 28%
Number of samples: 141



Map 64. Distribution of samples of Saltmarsh (Map Unit 64) shown by large black squares. Samples of other map units shown as small grey points.

Plate 64. Saltmarsh (Map Unit 64) dominated by *Sclerostegia arbuscula* and *Sarcocornia quinqueflora* with occasional *Avicennia marina* on the southern shore of Merimbula Lake. Estuarine Wetland Scrub appears in the background.

Table 64a. Diagnostic plant species of Map Unit 64.

Species	Target frequency	Target C/A	Fidelity class
Sarcocornia quinqueflora subsp. *quinqueflora*	0.716	3(1–5)	positive
Juncus kraussii	0.369	3(1–4)	positive
Samolus repens	0.319	3(1–4)	positive
Sporobolus virginicus	0.319	3(1–4)	positive
Austrostipa stipoides	0.220	4(3–5)	positive
Avicennia marina	0.184	3(3–4)	positive
Limonium australe	0.170	1(1–4)	positive
Sclerostegia arbuscula	0.163	4(3–4)	positive
Selliera radicans	0.142	3(1–3.75)	positive
Baumea juncea	0.142	3(1.5–5)	positive
Suaeda australis	0.142	1(1–3)	positive
Apium prostratum	0.135	1(1–1)	positive
Melaleuca armillaris	0.106	5(4–5)	positive
Zoysia macrantha	0.106	4(3–5)	positive
Atriplex australasica	0.099	1(1–1)	positive
Gahnia filum	0.092	1(1–3)	positive
Wilsonia backhousei	0.078	4(4–4)	positive
Phragmites australis	0.078	3(3–4)	positive
Disphyma crassifolium subsp. *clavellatum*	0.078	3(1–3)	positive
Myoporum acuminatum	0.064	3(3–4)	positive
Isolepis nodosa	0.064	1(1–1)	positive
Aegiceras corniculatum	0.050	4(3–4)	positive
Melaleuca ericifolia	0.043	4.5(3.75–6)	positive
Triglochin striata	0.035	1(1–3)	positive
Lobelia alata	0.036	1(1–1)	positive
Carpobrotus glaucescens	0.028	1(1–1)	positive
Rhagodia candolleana	0.028	1(1–1)	positive
Tetragonia tetragonoides	0.028	1(1–1)	positive
Juncus usitatus	0.014	1(1–1)	positive
Pseudognaphalium luteoalbum	0.014	1(1–1)	positive
Carex pumila	0.007	1(1–1)	positive
Mimulus repens	0.007	1(1–1)	positive

Map Unit 65: Estuarine Wetland (River Mangrove)

No quantitative data are available for this assemblage. The dominant species is *Aegiceras corniculata* which varies in stature from a shrub to a small tree. There may be a sparse cover of herbaceous species which are associated more commonly with Saltmarsh (Map Unit 64). Estuarine Wetland (River Mangrove) is restricted to the upper tidal zone on mudflats. The principal occurrence is at Merimbula Lake where the dominant species reaches its southern limit. This is a small stand, although *A. corniculata* also occurs as an emergent in Saltmarsh of other estuaries within the region (e.g. Bermagui River). Its distribution continues further north along the New South Wales coast. Mangroves have an important role in estuarine productivity and in supporting breeding populations of fish and other marine organisms. The principal threats entail degradation associated with foreshore and catchment development, and intensifying recreational use of the lake.

Species richness: no data
Extant area: 1 ha
Proportion cleared: 0%
Number of samples: 0

Map Unit 66: Estuarine Wetland (Grey Mangrove)

No quantitative data are available for this unit. The dominant species is *Avicennia marina* which varies in stature from a shrub to a small tree and usually occurs in pure stands. Occasional co-occurring species include *Aegiceras corniculata* and some herbaceous species which are associated more commonly with Saltmarsh (Map Unit 64). Estuarine Wetland (Grey Mangrove) is restricted to the lower tidal zone on mudflats. It is more widespread and in more frequently inundated habitat than River Mangrove (Map Unit 65). Small stands are scattered from Wonboyn to Wallaga Lake and extend well north along the coast. Mangroves have an important role in estuarine productivity and in supporting breeding populations of fish and other marine organisms. Most stands of Grey Mangrove adjoin freehold or crown land, although many of these are protected from direct disturbance under NSW state environmental planning policy. As for River Mangrove (Map Unit 65), the principal threats entail degradation associated with foreshore and catchment development, and intensifying recreational use of coastal lakes and estuaries.

Species richness: no data
Extant area: 101 ha
Proportion cleared: 19%
Number of samples: 0

Plate 65. Grey Mangrove (Map Unit 66) with *Avicennia marina* adjacent to open water on the southern shore of Merimbula Lake.

Map Unit 67: Seagrass Meadows (*Halophila*)

No quantitative data are available for this unit. The dominant species is *Halophila ovalis* which may co-occur with other seagrass species (Map Units 68–70). Seagrass Meadows (*Halophila*) are restricted to soft substrates in the sub-tidal zone of coastal estuaries. The principal stands are in Wallagoot and Cuttagee Lakes, with a smaller stand in Wallaga Lake. Similar assemblages are likely to occur in estuaries further north and south. More work is required to establish its relationship to other seagrass assemblages. Sea grass meadows have an important role in estuarine productivity and in supporting breeding populations of fish and other marine organisms. Potential threats include degradation caused by development or pasture improvement in estuary catchments, although the relevant catchments are partially protected in conservation reserves.

Species richness: no data
Extant area: 108 ha
Proportion cleared: -
Number of samples: 0

Map Unit 68: Seagrass Meadows (*Posidonia*)

No quantitative data are available for this unit. The dominant species is *Posidonia australis* which may co-occur with other seagrass species (Map Units 67, 69 & 70). Seagrass Meadows (*Posidonia*) are restricted to soft substrates in the sub-tidal zone of coastal estuaries. The principal stands are in Merimbula Lake and the Bermagui River estuary, although its distribution extends well north and south of the study area. More work is required to establish its relationship to other seagrass assemblages in the region. Sea grass meadows have an important role in estuarine productivity and in supporting breeding populations of fish and other marine organisms. Potential threats include degradation caused by development or pasture improvement in estuary catchments.

Species richness: no data
Extant area: 130 ha
Proportion cleared: -
Number of samples: 0

Map Unit 69: Seagrass Meadows (*Ruppia*)

No quantitative data are available for this unit. The dominant species are *Ruppia polycarpa* and *R. megacarpa* which may co-occur with other seagrass species (Map Units 67, 68 & 70). Seagrass Meadows (*Ruppia*) are restricted to soft substrates in the sub-tidal zone of coastal estuaries. Scattered occurrences include Curalo Lagoon near Eden, Middle Lagoon, Baragoot Lake and Wallaga Lake. Similar assemblages are likely to occur in estuaries further north and south. More work is required to establish its relationship to other seagrass assemblages in the region. Sea grass meadows have an important role in estuarine productivity and in supporting breeding populations of fish and other marine organisms. Potential threats include degradation caused by

development or pasture improvement in estuary catchments, although the some of the catchments are partially protected in conservation reserves.

Species richness: no data
Extant area: 56 ha
Proportion cleared: -
Number of samples: 0

Map Unit 70: Seagrass Meadows (*Zostera*)

No quantitative data are available for this unit. The dominant species is *Zostera capricorni* which may co-occur with other seagrass species (Map Units 67–69). Seagrass Meadows (*Zostera*) are restricted to soft substrates in the sub-tidal zone of coastal estuaries. Further work is required to establish its relationship to other seagrass assemblages in the region. This is the most widespread seagrass assemblage in the Eden region, with occurrences in most coastal lagoon and estuaries between Wonboyn and Wallaga Lakes. Similar assemblages are likely to occur in estuaries further north and south. Sea grass meadows have an important role in estuarine productivity and in supporting breeding populations of fish and other marine organisms. Potential threats include degradation caused by development or pasture improvement in estuary catchments, although some of these catchments are partially protected in conservation reserves.

Species richness: no data
Extant area: 423 ha
Proportion cleared: -
Number of samples: 0

Plate 66. An example of Sea Grass Meadows dominated by *Zostera capricorni* (Map Unit 70) in the shallows of Corunna Lake.

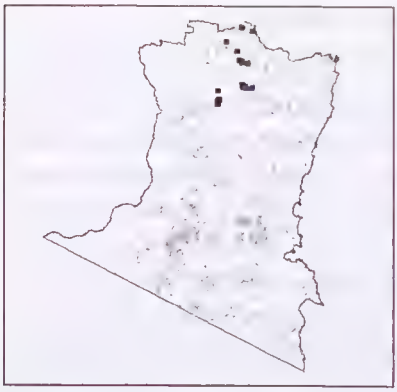
Map Unit W1: Wadbilliga Dry Shrub Forest

Wadbilliga Dry Shrub Forest is dominated by a variable mixture of ash and stringybark eucalypts including *E. fraxinoides, E. globoidea* and *E. agglomerata* as the most frequent species. A prominent stratum of sclerophyllous shrubs includes *Acacia obtusifolia, Leucopogon lanceolatus, Podolobium ilicifolium, Persoonia linearis* and *Platysace lanceolata.* The sparse groundcover includes *Dianella caerulea* and *Lomandra longifolia.* Wadbilliga Dry Shrub Forest occupies narrow ridges and upper slopes on metasediments at 400–1000 m elevation. It is likely to extend north of the Eden region in similar dissected terrain. Its rugged and inaccessible habitat and its distribution almost entirely within Wadbilliga National Park have protected this assemblage from past clearing activities. Although not currently threatened, increases in fire frequency would very likely result in losses of species diversity if an increase in ignitions occurred in future. Frequent fire regimes reduce diversity by interrupting life-cycle processes of woody species (Keith 1996). Intervals between planned and unplanned fires need to be long enough to allow replenishment of seed banks and restoration of habitat structure if losses of diversity are to be avoided.

Species richness: 18 ± 1 (0.05 ha)
Extant area: 27 336 ha
Proportion cleared: 0%
Number of samples: 28

Table 65a. Diagnostic plant species of Map Unit W1.

Species	Target frequency	Residual frequency	Fidelity class
Acacia obtusifolia	0.6	0.054	positive
Allocasuarina distyla	0.025	0	positive
Dianella caerulea	0.65	0.257	positive
Eucalyptus blaxlandii	0.025	0	positive
Leucopogon lanceolatus var. *lanceolatus*	0.8	0.062	positive
Podolobium ilicifolium	0.575	0.08	positive
Persoonia linearis	0.85	0.270	positive
Platysace lanceolata	0.75	0.264	positive
Lomandra longifolia	0.65	0.537	frequent
Eucalyptus agglomerata	0.25	0.090	uninformative
Eucalyptus consideniana	0.05	0.011	uninformative
Eucalyptus cypellocarpa	0.2	0.307	uninformative
Eucalyptus dalrympleana subsp. *dalrympleana*	0.05	0.040	uninformative
Eucalyptus elata	0.15	0.114	uninformative
Eucalyptus fastigata	0.1	0.167	uninformative
Eucalyptus fraxinoides	0.35	0.047	uninformative
Eucalyptus globoidea	0.3	0.228	uninformative
Eucalyptus muelleriana	0.1	0.117	uninformative
Eucalyptus radiata	0.125	0.073	uninformative
Eucalyptus smithii	0.075	0.058	uninformative
Poa meionectes	0.275	0.590	negative
Pteridium esculentum	0.45	0.558	negative



Map 65. Distribution of samples of Wadbilliga Dry Shrub Forest (Map Unit W1) shown by large black squares. Samples of other map units shown as small grey points.

Plate 67. Wadbilliga Dry Shrub Forest (Map Unit W1) dominated by *Eucalyptus sieberi* with *Podolobium ilicifolium, Xanthorrhoea concava* and *Lomandra confertifolia* ssp. *similis* near the eastern end of the Razorback Trail, Wadbilliga National Park.

Table 65b. Habitat characteristics of Map Unit W1. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5° and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

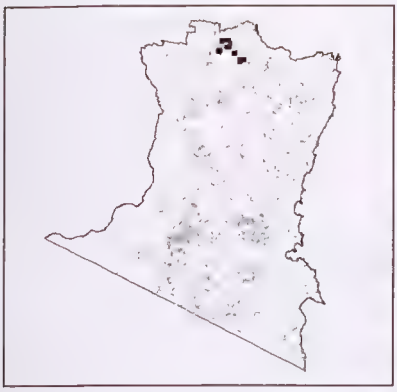
	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		930	911–949	28
Altitude (m)		686	553–810	28
Slope (degrees)		22	11–35	28
Terrain class				
North	36			10
Intermediate	25			7
South	21			6
Flat	18			5
Parent material				
Devonian granitoids	7			2
Devonian high quartz sedimentaries	75			21
Low quartz sedimentaries	14			4
Ordovician high quartz sedimentaries	4			1

Map Unit W2: Wadbilliga Range Shrub Forest

Wadbilliga Range Shrub Forest is dominated by *Eucalyptus fraxinoides* with *E. fastigata* or *E. pauciflora*. A prominent shrub stratum includes *Acrotriche serrulata, Banksia canei, Choretrum candollei, Oxylobium ellipticum, Persoonia silvatica* and *Platysace lanceolata*. The groundcover includes herbs *Dianella tasmanica, Stylidium graminifolium* and matrush *Lomandra longifolia*. This assemblage has a more uniform tree stratum and less sclerophyllous understorey than Wadbilliga Dry Shrub Forest (W1) and differs from Mountain Intermediate Shrub Forest (Map Unit 41) in the composition of sub-dominant tree species, as well as major understorey species. Wadbilliga Range Shrub Forest occupies metamorphosed sandstone at 1000–1300 m elevation on steep

sheltered upper slopes. It thus occurs at higher elevation than Map Units W1 and 41, and is found exclusively around the Wadbilliga Mountain plateau and associated ridges in Wadbilliga National Park. Similar assemblages may extend further north in rough terrain (Austin 1978, CSIRO 1996), while to the south it grades into Mountain Intermediate Shrub Forest (Map Unit 41) around Brown Mountain. Although not currently threatened, increases in fire frequency would very likely result in losses of species diversity if an increase in ignitions occurred in future. Frequent fire regimes reduce diversity by interrupting life-cycle processes of woody species (Keith 1996). Intervals between planned and unplanned fires need to be long enough to allow replenishment of seed banks and restoration of habitat structure if losses of diversity are to be avoided.

Species richness: 20 ± 1 (0.05 ha)
Extant area: 933 ha
Proportion cleared: 0%
Number of samples: 15



Map 66. Distribution of samples of Wadbilliga Range Shrub Forest (Map Unit W2) shown by large black squares. Samples of other map units shown as small grey points.

Plate 68. Wadbilliga Range Shrub Forest (Map Unit W2) dominated by *Eucalyptus fraxinoides* with *Persoonia silvatica, Leucopogon gelidus, Oxylobium arborescens* and *Choretrum candollei* on the Razorback Trail, Wadbilliga National Park.

Table 66a. Diagnostic plant species of Map Unit W2.

Species	Target frequency	Residual frequency	Fidelity class
Acrotriche serrulata	0.875	0.048	positive
Banksia canei	0.625	0.017	positive
Choretrum candollei	0.563	0.014	positive
Deyeuxia rodwayi	0.063	0	positive
Dianella tasmanica	0.625	0.247	positive
Eucalyptus fraxinoides	0.813	0.046	positive
Oxylobium ellipticum	0.938	0.013	positive
Persoonia silvatica	0.563	0.061	positive
Platysace lanceolata	0.813	0.272	positive
Stylidium graminifolium	0.688	0.143	positive
Lomandra longifolia	0.625	0.540	frequent
Eucalyptus dalrympleana subsp. *dalrympleana*	0.125	0.038	uninformative
Eucalyptus fastigata	0.313	0.163	uninformative

Species	Target frequency	Residual frequency	Fidelity class
Eucalyptus latiuscula	0.125	0.002	uninformative
Eucalyptus nitens	0.25	0.012	uninformative
Eucalyptus pauciflora	0.313	0.019	uninformative
Eucalyptus sieberi	0.125	0.286	uninformative
Poa meionectes	0.313	0.584	negative
Pteridium esculentum	0.438	0.556	negative

Table 66b. Habitat characteristics of Map Unit W2. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5° and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		973	939–1004	15
Altitude (m)		1173	1133–1225	14
Slope (degrees)		16	6–26	14
Terrain class				
North	7			1
Intermediate	36			5
South	36			5
Flat	21			3
Parent material				
Devonian high quartz sedimentaries	93			14
Low quartz sedimentaries	7			1

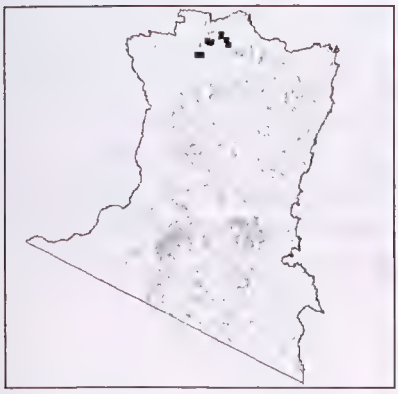
Map Unit W3: Wadbilliga Heath Forest

Wadbilliga Heath Forest is dominated by *Eucalyptus kybeanensis* with *E. pauciflora* or *E. dalrympleana*. A prominent shrub stratum includes *Banksia canei, Dillwynia sericea, Hibbertia pedunculata, Kunzea* sp. C, *Oxylobium ellipticum* and *Platysace lanceolata*. The groundcover includes *Gahnia sieberiana* and *Stylidium graminifolium*. Wadbilliga Heath Forest occupies dry sites on a metamorphosed sandstone plateau at 1100–1350 m elevation. It occupies more exposed sites than Northern Ash Dry Forest (Map Unit W2) and less exposed sites than Montane Heath (Map Unit 53). This assemblage is distinguished from the latter by the presence of a tree stratum and a more open shrub stratum. It is found almost exclusively on the Wadbilliga Mountain plateau and associated ridges to the south-west within Wadbilliga National Park. Although not currently threatened, extremes in fire frequency, if sustained, would very likely result in losses of species diversity. The most western stands may have been exposed to higher frequencies prior to park dedication (unpubl. data). Frequent fire regimes reduce diversity by interrupting life-cycle processes of woody species (Keith 1996). Intervals between planned and unplanned fires need to be long enough to allow replenishment of seed banks and restoration of habitat structure if losses of diversity are to be avoided.

Species richness: 20 ± 2 (0.05 ha)
Extant area: 1683 ha
Proportion cleared: 0%
Number of samples: 13

Table 67a. Diagnostic plant species of Map Unit W3.

Species	Target frequency	Residual frequency	Fidelity class
Allocasuarina nana	0.667	0.010	positive
Boronia algida	0.533	0	positive
Dillwynia sericea	0.667	0.007	positive
Epacris robusta	0.267	0	positive
Eucalyptus kybeanensis	0.6	0	positive
Eucalyptus paliformis	0.067	0	positive
Gahnia sieberiana	0.8	0.082	positive
Hakea dactyloides	0.733	0.014	positive
Hibbertia pedunculata	0.533	0.002	positive
Kunzea sp. C	0.6	0.002	positive
Leptospermum lanigerum	0.733	0.013	positive
Monotoca scoparia	0.533	0.134	positive
Platysace lanceolata	0.6	0.275	positive
Schoenus ericetorum	0.067	0	positive
Stylidium graminifolium	0.533	0.145	positive
Eucalyptus dalrympleana subsp. *dalrympleana*	0.4	0.035	uninformative
Eucalyptus fraxinoides	0.067	0.056	uninformative
Eucalyptus latiuscula	0.133	0.002	uninformative
Eucalyptus pauciflora	0.333	0.019	uninformative
Eucalytpus radiata	0.133	0.074	uninformative
Eucalytpus sieberi	0.067	0.286	uninformative
Lomandra longifolia	0.333	0.543	negative
Poa meionectes	0.133	0.586	negative
Pteridium esculentum	0	0.561	negative



Map 67. Distribution of samples of Wadbilliga Heath Forest (Map Unit W3) shown by large black squares. Samples of other map units shown as small grey points.

Plate 69. Wadbilliga Heath Forest (Map Unit W3) with *Eucalyptus pauciflora, E. latiuscula, Banksia canei, Kunzea* sp. C and *Leptospermum myrtifolium* south of Wadbilliga trig on the Razorback Trail, Wadbilliga National Park.

Table 67b. Habitat characteristics of Map Unit W3. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5° and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		956	888–1008	13
Altitude (m)		1197	1120–1260	13
Slope (degrees)		12	3–19	13
Terrain class				
North	15			2
Intermediate	15			2
South	38			5
Flat	31			4
Parent material				
Devonian high quartz sedimentaries	85			11
Low quartz sedimentaries	15			2

Map Unit W4: Kydra Flats Grass Forest

Kydra Flats Grass Forest has a variable tree stratum most frequently dominated by *Eucalyptus viminalis*, and *E. dalrympleana* with *E. radiata* or *E. fraxinoides*. An open shrub stratum includes *Leucopogon lanceolatus*, *Lomatia myricoides* and *Persoonia silvatica*. The prominent groundcover includes grasses and graminoids *Poa clivicola*, *P. meionectes* and *Lomandra longifolia*, herbs *Dianella tasmanica* and *Senecio glomeratus*, the vine *Clematis aristata* and bracken *Pteridium esculentum*. Kydra Flats Grass Forest occupies flats and sheltered slopes on metasediments at 1000–1200 m elevation. It has a more variable tree stratum and more prominent shrub stratum than other assemblages on flats at lower elevation on different substrates. It is restricted to transitional terrain between the Wadbilliga range and the Monaro plain in the upper Tuross and upper Brogo River catchments and may extend further north along the eastern edge of the Monaro. About 10% of this unit has been cleared, while much of the remainder is within Wadbilliga National Park. Stands that remain outside the reserve are exposed to moderate grazing pressure. The rural interface may be subject to high fire frequencies in certain locations. Frequent fire regimes reduce diversity by interrupting life-cycle processes of woody species (Keith 1996). Intervals between planned and unplanned fires need to be long enough to allow replenishment of seed banks and restoration of habitat structure if losses of diversity are to be avoided.

Species richness: 24 ± 2 (0.05 ha)
Extant area: 3098 ha
Proportion cleared: 9%
Number of samples: 6

Table 68a. Diagnostic plant species of Map Unit W4.

Species	Target frequency	Residual frequency	Fidelity class
Clematis aristata	0.643	0.337	positive
Dianella tasmanica	0.643	0.247	positive
Leucopogon lanceolatus var. *lanceolatus*	0.643	0.079	positive
Lomatia fraseri	0.5	0.034	positive
Persoonia silvatica	0.5	0.062	positive
Poa clivicola	0.571	0.0048	positive
Podolepis robusta	0.071	0	positive
Senecio glomeratus	0.714	0.020	positive
Lomandra longifolia	0.786	0.538	frequent
Poa meionectes	0.714	0.579	frequent
Pteridium esculentum	0.857	0.551	frequent
Elaeocarpus holopetalus	0.143	0.021	uninformative
Eucalyptus cypellocarpa	0.143	0.305	uninformative
Eucalyptus dalrympleana subsp. *dalrympleana*	0.357	0.036	uninformative
Eucalyptus fraxinoides	0.286	0.054	uninformative
Eucalyptus muelleriana	0.071	0.117	uninformative
Eucalyptus radiata	0.286	0.073	uninformative
Eucalyptus sieberi	0.071	0.286	uninformative
Eucalyptus viminalis	0.357	0.054	uninformative

Table 68b. Habitat characteristics of Map Unit W4. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5° and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		848	827–858	6
Altitude (m)		1083	1053–1108	6
Slope (degrees)		7	4–10	6
Terrain class				
North	17			1
Intermediate	33			2
South	17			1
Flat	33			2
Parent material				
Devonian granitoids	17			1
Devonian high quartz sedimentaries	33			2
Low quartz sedimentaries	50			3

Map 68. Distribution of samples of Kydra Flats Grass Forest (Map Unit W4) shown by large black squares. Samples of other map units shown as small grey points.

Plate 70. Kydra Flats Grass Forest (Map Unit W4) dominated by *Eucalyptus dalrympleana* and *E. fastigata* with *E. radiata, Acacia dealbata, Lomatia fraseri, Poa meionectes* and *Dianella tasmanica* near the intersection of Kydra and Razorback trails, Wadbilliga National Park.

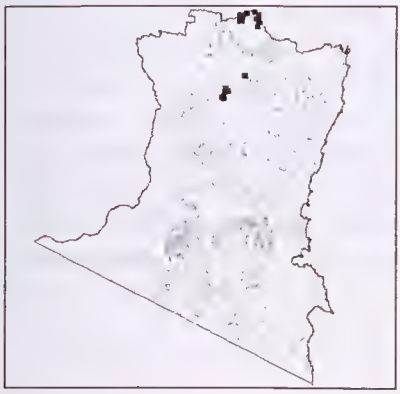
Map Unit W5: Wadbilliga Gorge Dry Forest

Wadbilliga Gorge Dry Forest is dominated by *Angophora floribunda* and *Eucalyptus globoidea* with a wide range of minor eucalypt species. *Allocasuarina littoralis* forms a prominent small tree stratum. The shrub stratum is sclerophyllous and highly variable in composition, *Persoonia linearis* being the most frequent species. The groundcover includes graminoids *Lomandra longifolia,* herbs *Oxalis perennans,* the vine *Glycine clandestina* and bracken *Pteridium esculentum.* Wadbilliga Gorge Dry Forest occupies steep to moderate dry slopes on metasediments and granitoid substrates at 200–500 m elevation. It differs from other assemblages in the dissected northern terrain in tree composition and the presence of a subcanopy, albeit patchy and probably extends further north in similar habitat. It is restricted to the gorges of Tuross and Brogo Rivers and their tributaries, principally within Wadbilliga National Park. Although not presently a serious threat, frequent fire regimes if they occurred would reduce diversity by interrupting life-cycle processes of woody species (Keith 1996). Intervals between planned and unplanned fires need to be long enough to allow replenishment of seed banks and restoration of habitat structure if losses of diversity are to be avoided.

Species richness: 22 ± 1 (0.05 ha)
Extant area: 7423 ha
Proportion cleared: 6%
Number of samples: 22

Table 69a. Diagnostic plant species of Map Unit W5.

Species	Target frequency	Residual frequency	Fidelity class
Allocasuarina littoralis	0.5	0.158	positive
Angophora floribunda	0.667	0.102	positive
Callitris endlicheri	0.095	0	positive
Cryptandra spinescens	0.024	0	positive
Eucalyptus globoidea	0.595	0.218	positive
Glycine clandestina	0.5	0.282	positive
Hibbertia riparia	0.048	0	positive
Mentha satureioides	0.119	0	positive
Oxalis perennans	0.571	0.204	positive
Persoonia linearis	0.810	0.271	positive
Pterostylis obtusa	0.0238	0	positive
Lomandra longifolia	0.786	0.532	frequent
Pteridium esculentum	0.548	0.554	frequent
Eucalyptus agglomerata	0.286	0.088	uninformative
Eucalyptus angophoroides	0.333	0.034	uninformative
Eucalyptus baueriana	0.024	0.016	uninformative
Eucalyptus bosistoana	0.024	0.033	uninformative
Eucalyptus consideniana	0.071	0.011	uninformative
Eucalyptus cypellocarpa	0.238	0.306	uninformative
Eucalyptus dives	0.048	0.011	uninformative
Eucalyptus elata	0.238	0.110	uninformative
Eucalyptus fastigata	0.071	0.168	uninformative
Eucalyptus maidenii	0.167	0.052	uninformative
Eucalyptus mannifera	0.048	0.001	uninformative
Eucalyptus muelleriana	0.191	0.114	uninformative
Eucalyptus radiata	0.048	0.076	uninformative
Eucalyptus sieberi	0.214	0.286	uninformative
Eucalyptus smithii	0.119	0.056	uninformative
Eucalyptus stenostoma	0.024	0.010	uninformative
Eucalyptus tereticornis	0.024	0.051	uninformative
Eucalyptus viminalis	0.071	0.056	uninformative
Poa meionectes	0.476	0.584	negative



Map 69. Distribution of samples of Wadbilliga Gorge Dry Forest (Map Unit W5) shown by large black squares. Samples of other map units shown as small grey points.

Plate 71 Wadbilliga Gorge Dry Forest (Map Unit W5) dominated by *Eucalyptus agglomerata* and *E. consideniana* with *Allocasuarina littoralis, Persoonia linearis* and *Dodonaea triquetra* on the lower slopes of the Wadbilliga River gorge, Wadbilliga trail, Wadbilliga National Park.

Table 69b. Habitat characteristics of Map Unit W5. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5° and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		948	905–990	22
Altitude (m)		372	243–478	22
Slope (degrees)		20	11–26	22
Terrain class				
North	45			10
Intermediate	45			10
South	9			2
Flat	0			0
Parent material				
Devonian granitoids	36			8
Devonian high quartz sedimentaries	18			4
Low quartz sedimentaries	18			4
Ordovician high quartz sedimentaries	27			6

Map Unit W6: Wadbilliga River Valley Forest

Wadbilliga River Valley Forest is dominated by *Eucalyptus elata* and *Angophora floribunda* occasionally with *E. viminalis* and a narrow band of *Casuarina cunninghamiana* along river banks. A prominent non-sclerophyllous shrub stratum is dominated by *Bursaria lasiophylla, Hymenanthera dentata, Lomatia myricoides* and *Phyllanthus gasstroemii.* The semi-continuous groundcover includes forbs *Dichondra repens, Oxalis perennans, Pratia purpurascens* and *Solanum pungetium,* ferns *Pellaea falcata* and *Pteridium esculentum,* grasses and graminoids *Entolasia marginata* and *Lomandra longifolia,* and the scrambling shrub *Rubus parvifolius.* Wadbilliga River Valley Forest occupies sheltered slopes in the lower gorges of the Tuross and Wadbilliga Rivers below 300 m elevation on metasediments and granitoid parent materials. Its combination of tree and shrub species distinguish it from other assemblages in the dissected northern terrain. Similar assemblages may occur north of the Eden region in gorge terrain, although occurrences are likely to be restricted. Some areas of Wadbilliga River Valley Forest may have been subject to rough grazing prior to dedication of Wadbilliga National Park, but past clearing has been negligible. Although not presently a serious threat, frequent fire regimes if they occurred would reduce diversity by interrupting life-cycle processes of woody species (Keith 1996). Intervals between planned and unplanned fires need to be long enough to allow replenishment of seed banks and restoration of habitat structure if losses of diversity are to be avoided.

Species richness: 33 ± 3 (0.05 ha)
Extant area: 1947 ha
Proportion cleared: 0%
Number of samples: 7

Map 70. Distribution of samples of Wadbilliga River Valley Forest (Map Unit W6) shown by large black squares. Samples of other map units shown as small grey points.

Plate 72 Wadbilliga River Valley Forest (Map Unit W6) dominated by *Eucalyptus elata* with *Casuarina cunninghamiana, Acacia floribunda, Cassinia trinerva* and *Hymenathera dentata* festooned with *Cissus hypoglauca* and *Smilax australis* along the Wadbilliga River flats and adjacent slopes, Wadbilliga National Park.

Table 70a. Diagnostic plant species of Map Unit W6.

Species	Target frequency	Residual frequency	Fidelity class
Angophora floribunda	0.539	0.117	positive
Bursaria lasiophylla	0.539	0.018	positive
Casuarina cunninghamiana	0.539	0.004	positive
Dichondra repens	0.769	0.248	positive
Entolasia marginata	0.692	0.060	positive
Eucalyptus elata	0.692	0.109	positive
Hymenanthera dentata	0.539	0.069	positive
Lomatia myricoides	0.615	0.077	positive
Oxalis perennans	0.692	0.212	positive
Pellaea falcata var. *falcata*	0.692	0.095	positive
Phyllanthus gasstroemii	0.615	0.011	positive
Pratia purpurascens	0.615	0.089	positive
Rubus parvifolia	0.539	0.125	positive
Solanum pungetium	0.539	0.071	positive
Lomandra longifolia	0.692	0.539	frequent
Pteridium esculentum	0.615	0.554	frequent
Eucalyptus angophoroides	0.077	0.044	uninformative
Eucalyptus badjensis	0.077	0.006	uninformative
Eucalyptus cypellocarpa	0.231	0.304	uninformative
Eucalyptus fastigata	0.077	0.166	uninformative
Eucalyptus fraxinoides	0.077	0.056	uninformative
Eucalyptus globoidea	0.154	0.231	uninformative
Eucalyptus maidenii	0.077	0.055	uninformative
Eucalyptus viminalis	0.385	0.054	uninformative
Poa meionectes	0.231	0.584	negative

Table 70b. Habitat characteristics of Map Unit W6. Means and interquartile ranges for altitude and slope were calculated from n field samples, while those for annual rain were calculated from ESOCLIM predictions (see Table 5, text). Frequency terrain and parent material refers to number of samples (n) recorded in respective classes. Terrain classes: flat (slope ≤ 5°); north (slope > 5° and aspect < 30° or > 300°); intermediate (slope > 5° and aspect 30–120° or 210–300°); and south (slope > 5° and aspect 120–210°).

	Frequency (%)	Mean	Interquartile Range	n
Annual rain (mm)		986	971–1003	7
Altitude (m)		199	180–228	7
Slope (degrees)		4	1–2	7
Terrain class				
North	14			1
Intermediate	0			0
South	0			0
Flat	86			6
Parent material				
Devonian granitoids	57			4
Devonian high quartz sedimentaries	29			2
Ordovician high quartz sedimentaries	14			1

Vascular Flora of the South East Forests region, Eden, New South Wales

David A. Keith, Jackie Miles and Berin D. E. Mackenzie

Abstract

Keith, David A.[1], Miles, Jackie[2], and Mackenzie, Berin, D. E.[1] ([1]NSW National Parks and Wildlife Service, PO Box 1967, Hurstville, NSW, *Australia 2220;* [2]*Hawkshead Road, Brogo, NSW, Australia 2550) 1999. Vascular flora of the South East Forests region, Eden, New South Wales.* Cunninghamia *6(1): 219–281.* An exhaustive review of available information revealed 1522 native vascular plant taxa with confirmed records in the Eden region. A further 136 taxa potentially occur in the region, but these remain to be confirmed. Families represented by large numbers of taxa in the indigenous flora include the Fabaceae, Poaceae, Asteraceae, Myrtaceae and Orchidaceae. Species frequencies were highly skewed with 74% of the flora represented in less than 1% of survey samples and only three taxa represented in more than 40% of samples. A large number of records (350 taxa) were evaluated and refuted, emphasising the importance of critical validation when compiling biological inventory data from multiple sources. Errors are most likely to arise from nomenclatural synonymy and other duplications, misidentifications and erroneous locality information.

The confirmed vascular flora of the Eden region is relatively species-rich compared with other regions in tropical, temperate and semi-arid Australia, although these regions are less well-known botanically. However, the proportion of endemism (1%) is comparatively low, with 18 taxa unique to the region and a further 14 taxa with distributions extending just beyond the region. The Eden region includes 32 taxa listed as endangered or vulnerable in Australia and a further six taxa listed as endangered in New South Wales but not throughout Australia. Thirty-eight taxa were listed as rare in Australia and a further 39 were considered to be uncommon throughout their distribution. Four hundred and sixty-six taxa were considered to be uncommon within the Eden region. Two hundred and seventy-six taxa reached their distributional limits in the Eden region, about three quarters of these reaching their southern limits. Fifty taxa were represented in the region by disjunct populations.

Introduced taxa accounted for approximately 20% of the total regional vascular flora, although this proportion is likely to underestimate the introduced flora given the limitations of available data. The introduced flora is dominated by Poaceae, Asteraceae, Fabaceae and Caryophyllaceae. Very few introduced taxa were widespread in native vegetation. The most common introduced taxa were herbs with long-distance propagule dispersal mechanisms.

Introduction

Botanical exploration of the South East Forests region of New South Wales probably began with Ferdinand von Mueller's expedition to Twofold Bay and the upper Genoa River in 1860. However, the flora of the region remained poorly known until 1980 when there was a sustained increase in botanical exploration and vegetation survey within the region. A checklist of vascular plants in the South East Forests region was first compiled by Binns (1987) and this was subsequently updated by Doherty (1996). In the last twenty years, the region has become one of the best botanically known in Australia, with the discovery of approximately twenty plant species new to science, most of which are largely restricted to the region, and the development of a comprehensive floristic data base and vegetation map (Keith & Bedward 1999).

Our principal aim in this paper was to compile a validated checklist of the region's indigenous and introduced vascular flora by critically reviewing all available information. Sources of information, including herbarium specimens, references in the scientific literature, survey records, unpublished accounts and anecdotal observations varied widely in their coverage and reliability. Although herbarium collections and treatments in the taxonomic literature were the most reliable sources, their coverage was generally patchy, biased and unrepresentative relative to the coverage of survey records. Furthermore, in the absence of complete data bases, herbarium collections are relatively inaccessible and costly to search fully for a given region. We therefore sought to validate or refute survey records, unpublished accounts and anecdotal records either by locating specimens held in herbarium collections, or by our own direct observations and collections from the field. To assist future work, we documented all unresolved records for the region.

A secondary aim of this study was to document the relative abundance and conservation significance of plant taxa in the region. These factors were assessed using the floristic data base, reference to schedules of threatened species and assessment against conservation criteria described previously by Keith (1990).

Methods

Study Area

The study area corresponds to the Eden Forest Management Area (State Forests of NSW 1996) and lies between latitudes 36°05'–37°35'S and longitudes 148°40'–150°10'E. (Fig. 1) in far south-eastern New South Wales. It is bounded by the Tasman Sea to the east, the NSW-Victorian border in the south, the Monaro Tableland to the west and a line following watercourses and ridgelines between Kybean and Bermagui in the north. The region rises from sea level in the east to over 1200 m elevation in the north-west and is dominated by a granitoid batholith and sedimentary rocks that are metamorphosed to varying degrees. For a more detailed description of the region's landscape, geology, climate, vegetation and land use history, see Keith & Bedward (1999).

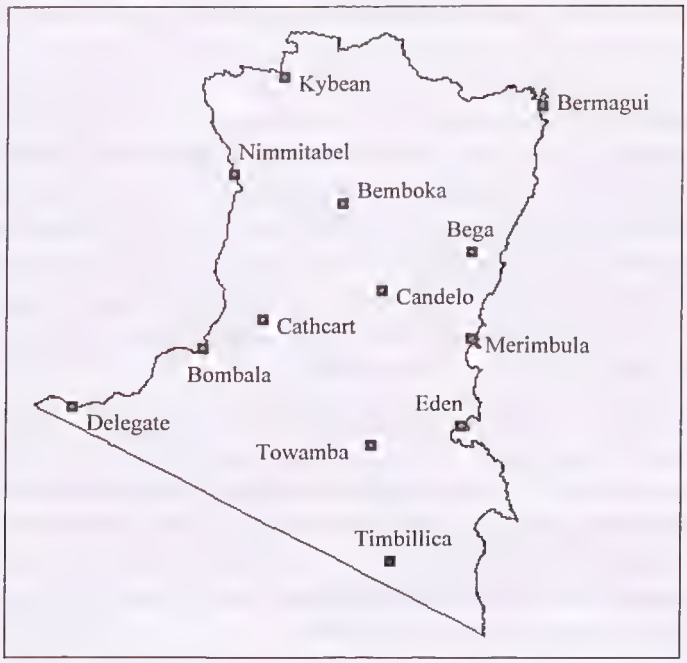


Fig. 1. South East Forests region study area.

Data compilation

A preliminary list of species was extracted from vegetation sample data compiled by Keith & Bedward (1999). This data set comprised 2906 samples of full floristic composition within quadrats mostly in the range 0.01–0.1 ha. The frequency of occurrence of each species among samples was recorded. Other species recorded previously by Binns (1987) and Keith & Ashby (1992) were added to this preliminary list.

Searches of herbarium collections held at Sydney (NSW), Canberra (ANBG) and Melbourne (MEL) were carried out to confirm survey records of each taxon on the preliminary list. Initially, the electronic databases held by NSW and ANBG were searched for all collections within the Eden region. The NSW database query was carried out on a minimal rectangle enclosing the study area bounded by latitudes 36°05'–37°35'S and longitudes 148°40'–150°10'E. The ANBG data base query was carried out on the NSW South Coast and Southern Tablelands botanical subdivisions (Anderson 1961). Records located within these query areas but outside the study area boundary were removed manually. Taxa on the preliminary list that were represented in the study area by a herbarium collection were transferred to a list of confirmed taxa. Searches of the herbarium data bases revealed numerous taxa that had not been recorded in the field survey and these were added to the confirmed list. Some other taxa that had been recorded during our field survey and verified with a specimen collection that was not retained in a public herbarium were also transferred to the confirmed list.

Herbarium collections held at NSW, ANBG and MEL were then searched manually for non databased records of taxa remaining on the preliminary list. While comprehensive herbarium searches for all taxa were precluded by constraints on time and resources, searches were carried out for most taxa on the residual list. As taxa were confirmed by herbarium collections, they were transferred to the confirmed list. For some taxa that remained unconfirmed by herbarium collections or other verified specimens, we consulted the taxonomic literature, taxonomic specialists and in some cases, the field botanists responsible for the original records. This yielded some hitherto unknown specimens or other convincing evidence that warranted transfer of some previously unresolved taxa to the confirmed list. Limited searches carried out in the field resulted in a small number of additional confirmations.

The origin and conservation significance of all listed taxa were assessed. Plants were determined as indigenous or introduced by consulting Harden (1990–1993). Australian native taxa were regarded as introduced if the study area was outside their known natural range and they were recorded only from disturbed habitats (e.g. wasteland, roadsides, regrowth) within the study area. Regional patterns of abundance were examined by calculating the frequency of occurrence of each taxon in the survey data set comprising 2906 samples.

The conservation significance of indigenous plant taxa was assessed using criteria described in Table 1 by updating the list in Keith & Ashby (1992) with newly available data. These criteria refer to varying levels of extinction risk (threat), habitat depletion, varying levels of rarity and endemism, and biogeographical phenomena such as distributional limits and disjunct populations (Table 1). The definitions of Criteria 2 and 3 were modified from earlier applications to accommodate schedules under the Commonwealth Endangered Species Protection Act (1992) and the NSW Threatened Species Conservation Act (1995). Criterion 2 now includes only taxa listed on one or both schedules. Criterion 3 now includes taxa listed in categories R (rare but not threatened in Australia) and K (poorly known) of Rare or Threatened Australian Plants (ROTAP, Briggs & Leigh 1996), as well as some additional taxa considered to be uncommon throughout their range. In previous applications of the criteria (Keith 1990, Keith & Ashby 1992), all taxa listed on ROTAP were included under Criterion 2, while only those considered uncommon throughout their range were included under Criterion 3. The definition of Criterion 5 has also been modified from previous applications to take advantage of the larger set of systematic survey data that is now available. Species were listed as regionally uncommon if present in less than $\leq 0.1\%$ of the survey records or if known to be represented only as very small populations scattered across the region. The identification of taxa presumed to be extinct within the region (Criterion 5X) is a further modification to previous applications of the criteria. There were too few collections of such taxa to permit statistical evaluation (e.g. Burgman et al. 1996), so taxa were presumed extinct in the region if they were not recorded for at least 50 years or if all known populations were known to be destroyed.

Table 1. Criteria for identification of plant taxa of conservation significance (modified from Keith 1990).

Criterion	Definition
1	Endemic to the region (i.e. found nowhere else).
2	Listed as threatened in Australia (E: endangered, V: vulnerable) on schedules of the Commonwealth Endangered Species Protection Act (1992) and/or in New South Wales (e: endangered, v: vulnerable) on schedules of the NSW Threatened Species Conservation Act (1995).
3	Rare (i.e. listed under category R by Briggs & Leigh 1996), poorly known and potentially rare or threatened (i.e. listed under category K by Briggs & Leigh 1996), or uncommon throughout range, but not threatened.
4	Restricted distribution outside region, but maybe locally common within region (i.e. majority of distribution falls within region).
5	Uncommon within region (occurring in 0.1% of samples unless otherwise known to be common, and/or in small populations).
5X	Presumed extinct within region if not recorded during last 50 years or if all populations known to be destroyed.
6	Habitat extensively depleted, or species harvested or collected, but not yet rare or threatened.
7	Geographic limit of distribution within the region (N: northern, S: southern limit, LN: local northern limit with disjunct population(s) known further north, LS: local southern limit with disjunct population(s) known further south).
8	Populations in the region disjunct from other occurrences of the taxon, usually separated by at least 100 km from other populations of the taxon.
9	Occupies habitat that is atypical relative to the majority of the taxon's distribution.

Botanical nomenclature

Botanical nomenclature was reviewed and standardised across all data sets. The names applied here therefore follow Harden (1990–1993) and changes subsequently accepted by the National Herbarium of NSW (e.g. Hill & Johnson 1995, Jacobs & Everett 1996, Linder & Verboom 1996, Briggs & Johnson 1998). Given that the data were compiled from numerous sources dated from 1979 to present, particular care was taken to resolve confounded taxonomy. Where two or more synonyms were applied to the same taxon in different data sets, these were updated to reflect currently accepted nomenclature. Where subspecific or varietal taxa were not always specified, the records were updated by adding the appropriate epithet if possible (e.g. if only one subspecies or variety was known from the region and nearby) or by reducing all the relevant records to species level.

Results and Discussion

Indigenous flora

The indigenous flora of the Eden region comprises a minimum of 1522 vascular plant taxa that were represented by confirmed records within the region (Appendix 1). Records of a further 136 taxa remain to be confirmed or refuted (Appendix 2). These

included 86 taxa with potentially reliable but unconfirmed records within the region and 28 taxa not recorded within the region, but recorded nearby in habitats similar to those known to occur within the region. Almost half (47%) of the 86 taxa with unconfirmed records were monocots and most of these were orchids (15 taxa), grasses (9 taxa) and sedges (12 taxa). The taxonomic status of 19 of the unconfirmed taxa was uncertain, while the identifications of a further two taxa were uncertain. All except three of these uncertain taxa were dicots. Records of 350 taxa have been definitively refuted. The refuted taxa included many synonyms, other duplicated records and some erroneous identifications. For example, a specimen of *Acronychia wilcoxii* held at the National Herbarium of New South Wales was examined and redetermined as *Sarcomeliocope simplicifolia*.

The confirmed vascular flora comprised 79 (5%) pteridophytes, 5 (0.3%) gymnosperms, 997 (66%) dicots and 441 (29%) monocots, while the list of unconfirmed taxa had similar proportions. Plant families with high levels of representation in the confirmed regional flora included Fabaceae (141 taxa), Poaceae (129 taxa), Asteraceae (114 taxa), Myrtaceae (107 taxa) and Orchidaceae (100 taxa). Genera with high levels of representation include *Eucalyptus* (63 taxa), *Acacia* (50 taxa), *Pomaderris* (26 taxa), *Pultenaea* (20 taxa), *Juncus* (20 taxa), *Hibbertia* (18 taxa) and *Austrostipa* (18 taxa).

Hybrids or intermediate forms have been recorded between 35 pairs of taxa (Table 2). Fifteen of these were eucalypts, while 24 belonged to the families Myrtaceae, Proteaceae and Juncaceae, reflecting both the propensity for hybridisation and introgression, and the high level of taxonomic interest in these groups over many years. Some of the intermediate taxa have extensive distributions that extend beyond the occurrence of their parent taxa (e.g. *Eucalyptus botryoides-saligna*). Others are represented by sporadic individuals whose occurrence is restricted to the vicinity of the parent taxa (e.g. *Pomaderris aspera* × *cinerea*, syn. *P.* sp. C, Harden 1990). Some of the intermediate taxa have been formally described in the literature (e.g. *Persoonia* × *lucida*, *Acaena* × *anserovina*).

The frequency distribution of taxa amongst samples was highly skewed (Fig. 2a). Only three taxa were represented in more than 40% of samples (*Lomandra longifolia* subsp.. *longifolia* 50.3%, *Pteridium esculentum* 50.0% and *Poa meionectes* 44.8%). Twenty-three taxa were represented in more than 20% of samples, while 1115 taxa (74% of total confirmed flora) were represented in less than 1% of samples (Fig. 2a). The 20 most frequently recorded taxa in the region included five grasses and graminoids, four herbs, four vines, three trees, three shrubs and one fern. The infrequent taxa included some whose distribution was marginal to the study area (e.g. *Schizomeria ovata*), some that were spatially restricted (e.g. *Grevillea acanthifolia* subsp. *paludosa*) or specific to highly restricted habitats (e.g. *Westringia davidii*), some that were distributed sparsely within widespread habitats (e.g. *Santalum obtusifolium*) and some that had conspicuous growth forms only after temporally rare events (e.g. *Prasophyllum brevilabre*). Geophytes, particularly Orchidaceae, were disproportionately represented in the tail of the species frequency distribution.

Table 2: Pairs of taxa for which intermediate forms have been recorded in the South East Forests region.

Acaena novazelandiae × *A. ovina* (*A.* × *anserovina*)

Banksia marginata × *B. paludosa*

Corymbia gummifera × *C. maculata*

Cyathea australis × *C. leichhardtiana* (*C.* × *marcescens*)

Daviesia buxifolia × *D. mimosoides*

Derwentia derwentiana subsp. *derwentiana* × *D. derwentiana* subsp. *maideniana*

Eucalyptus agglomerata × *E. globoidea*

Eucalyptus baueriana × *E. bosistoana*

Eucalyptus bosistoana × *E. paniculata*

Eucalyptus botryoides × *E. saligna*

Eucalyptus camphora subsp. *humeana* × *E. ovata*

Eucalyptus camphora subsp. *humeana* × *E. viminalis*

Eucalyptus dives × *E. radiata*

Eucalyptus elata × *E. radiata*

Eucalyptus elata × *E. sieberi*

Eucalyptus globoidea × *E. yangoura*

Eucalyptus kybeanensis × *E. latiuscula*

Eucalyptus parvula × *E. viminalis*

Eucalyptus pauciflora × *E.* ?*dives*

Grevillea baueri × *G. lanigera*

Juncus australis × *J. filicaulis*

Juncus australis × *J. melanobasis*

Juncus filicaulis × *J. subsecundus*

Juncus fockei × *J. holoschoenus*

Juncus mollis × *J. usitatus*

Lomandra longifolia × *L. confertifolia*

Lomatia fraseri × *L. myricoides*

Olearia erubescens × *O. megalophylla*

Persoonia asperula × *P. chamaepeuce*

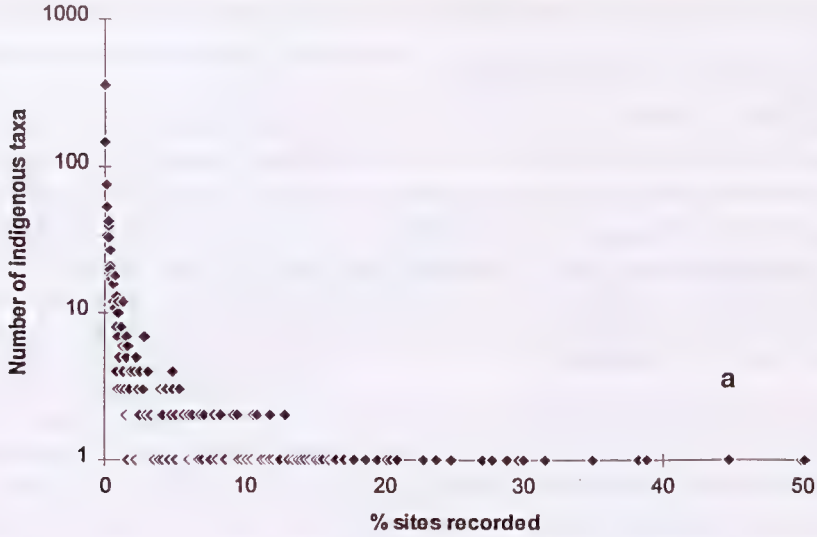
Persoonia levis × *P. linearis* (*P.* × *lucida*)

Phebalium squamulosum subsp. *squamulosum* × *P. squamulosum* subsp. *argenteum*

Pittosporum undulatum × *P. bicolor*

Pomaderris aspera × *P. cinerea* (*P.* sp. C)

Xanthorrhoea australis × *X. resinifera*



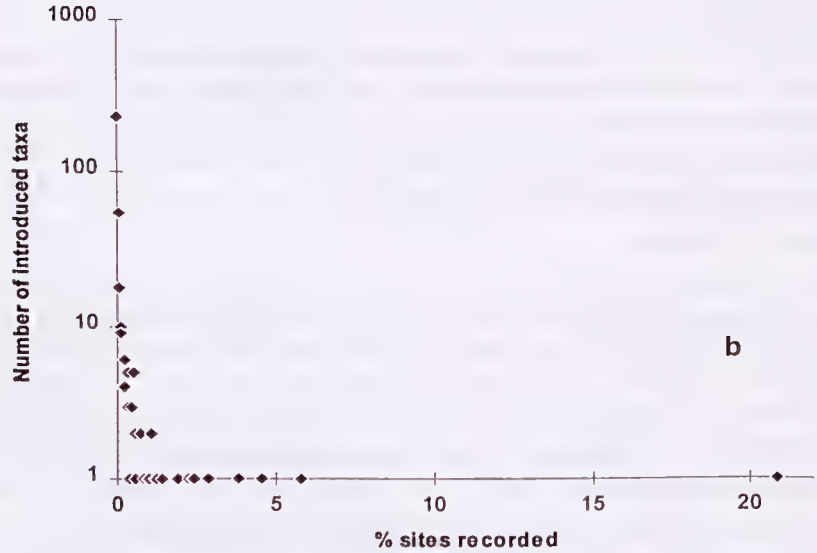


Fig. 2. Frequency distribution of species among 2906 samples: a, indigenous flora; and b, introduced flora.

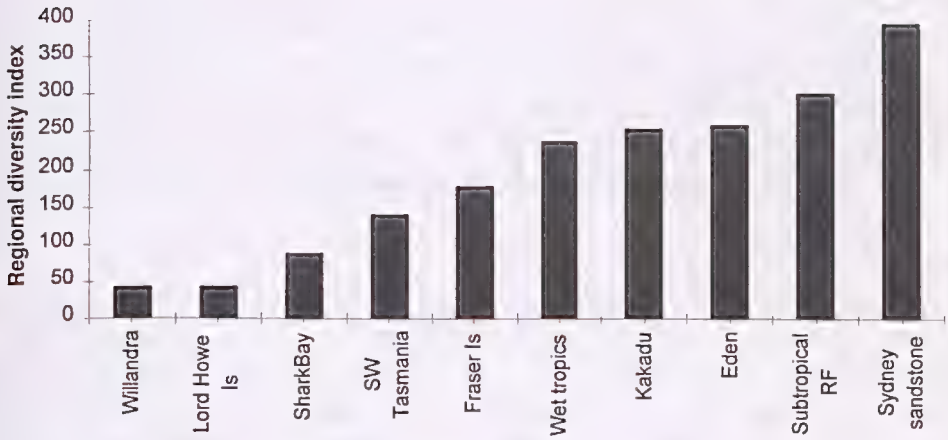


Fig. 3. Regional diversity index (D=S/logA, see text) for vascular flora of ten regions (data from James (1994) except Eden, this study).

Comparisons with other regional floras must be made with caution, because Eden has had a higher level of botanical exploration than most other regions except the Sydney region, while tropical regions in particular, are poorly known. Nonetheless, the indigenous Eden regional flora is comparatively diverse, relative to other Australian regional floras (Fig. 3, James 1994). The floristic diversity of the Eden region was compared with that of other Australian regions assuming an exponential species-area relationship to calculate a regional diversity index D=S/logA, where S is the number of taxa in the region and A is the area of the region in hectares. The Eden region has a comparatively rich flora (1522 spp.) for an area of its size (810 000 ha). Tropical regions such as north-east Queensland Wet Tropics (900 000 ha) and Kakadu National Park (2 000 000 ha) have similar diversity indices, with 1400 and 1600 vascular plant taxa, respectively, although the latter region is two and a half times the size of the Eden region. Semi-arid regions such as Willandra Lakes and Shark Bay World Heritage Areas have less diverse floras (240 spp. in 600 000 ha and 620 spp. in 15 000 000 ha, respectively), as does the cool temperate western Tasmanian wilderness (860 spp., 1 400 000 ha) and the Fraser Island/Cooloola subtropical sand mass (920 spp., 160 000 ha). However, the flora of the Eden region is less diverse than that of the Sydney sandstone region (2500 spp., 1 900 000 ha), and the East Coast subtropical rainforest parks (1600 spp., although this latter 'region' comprises several disjunct areas totalling 270 000 ha).

The Eden region has a comparatively low level of floristic endemism (1.1% cf. 5–36% for all other regions except Kakadu and Willandra, Fig. 4). Island floras and rainforest floras had the highest proportion of endemic taxa.

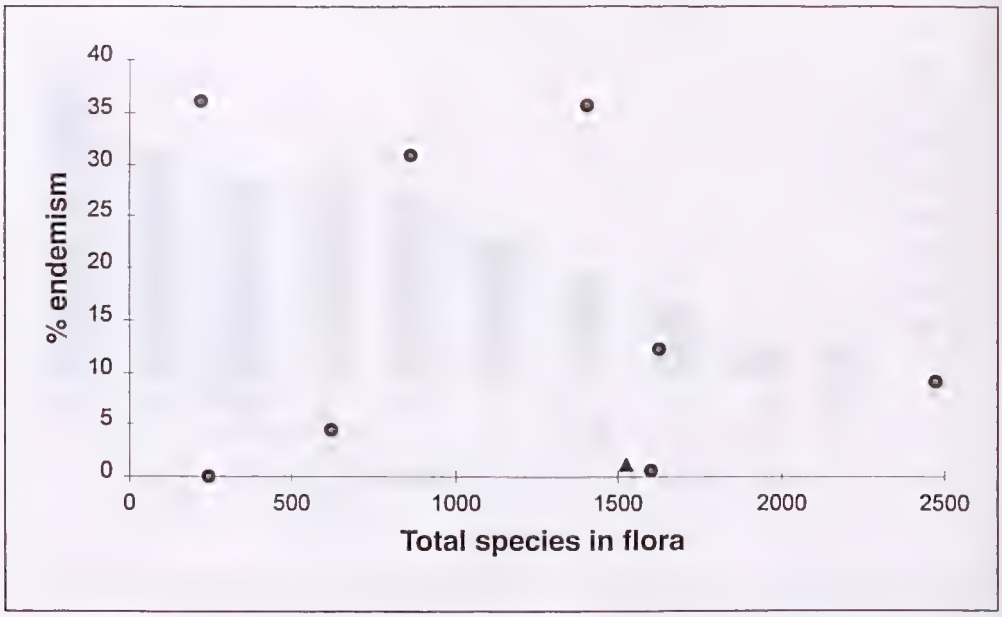


Fig. 4. Endemism in eight regional floras (round symbols, data from James 1994), compared with Eden (triangular symbol).

Plant species of special conservation significance

Almost 700 taxa listed in Appendix 1 met one or more of the nine conservation criteria described in Table 1. Thirty-eight taxa (Tables 3 & 4) were listed as threatened on schedules of the Commonwealth Endangered Species Protection Act (1992), the NSW Threatened Species Conservation Act (1995) or both (Criterion 2). Several of these were either endemic (Category 1, 12 taxa) or largely restricted to the Eden region (Criterion 4, 3 taxa). Six additional endemic taxa and eleven further taxa largely confined to the region were not currently listed as threatened. Eleven of the 38 threatened taxa were endangered nationally, while a further six were endangered in New South Wales (Table 3). The remaining 21 threatened taxa were vulnerable, both in Australia and New South Wales.

Thirty-eight of the 77 taxa considered rare or uncommon throughout their range (Criterion 3, Table 4) were listed as nationally rare by Briggs & Leigh (1996), including three regional endemics (Criterion 1) and seven taxa largely restricted to the Eden region (Criterion 4, Table 4). Of the remaining 39 taxa listed under Category 3, a few are yet to be assessed for listing under state and commonwealth legislation (e.g. *Astrotricha* sp. (Nadgee), *Grevillea irrassa* subspecies). Four hundred and sixty-six taxa were considered uncommon within the region (Category 5, Table 4), although these may be common elsewhere.

Eighteen taxa persist as relict populations in depleted, fragmented habitats or have populations depleted by collecting or harvesting activities (Category 6, Table 4). Most of these taxa occur in widespread habitats that have been extensively cleared or modified, but they may still persist in reasonable numbers throughout their full range.

Table 3. Threatened and rare taxa occurring in the South East Forests region. Aust. indicates status on the schedule of the Commonwealth Endangered Species Protection Act 1992 (E: Endangered and V: Vulnerable, respectively, in Australia); NSW indicates status on the schedule of the NSW Threatened Species Conservation Act 1995 (e: endangered and v: vulnerable, respectively, in NSW); and ROTAP indicates taxa considered rare in Australia but not threatened by Briggs & Leigh 1996 (2: distributional range < 100 km, 3: range > 100 km, R: rare but not threatened in Australia, C: represented in a conservation reserve, a: more than 1000 plants known from a conservation reserve, i: less than 1000 plants known from a conservation reserve, t: total distribution contained within a conservation reserve).

	Conservation Status		
	Aust.	NSW	ROTAP
Acacia blayana			2RC-
Acacia constablei	V	v	
Acacia costiniana			3RCa
Acacia covenyi			2RCa
Acacia georgensis	V	v	
Acacia kydrensis			2RCa
Acacia lucasii			3RCa
Acacia subtilinervis			3RCa
Asplenium obtusatum	V		
Baeckea denticulata			3RCa
Boronia deanei	V	v	
Burnettia cuneata			3RC-
Caladenia tesselata	V	v	
Calotis glandulosa	V	v	
Carex capillacea			3RC-
Correa baeuerlenii	V	v	
Cryptostylis hunteriana	V	v	
Dampiera fusca			3RCi
Daviesia suaveolens			3RCa
Deyeuxia talariata			3RCi
Dichelachne parva	V		
Discaria pubescens			3RCa
Diuris ochroma	V		
Diuris pedunculata	E	e	
Dodonaea procumbens	V	v	
Dodonaea rhombifolia			3RCa
Eucalyptus badjensis			2RCi
Eucalyptus baeuerlenii			3RCa
Eucalyptus gregsoniana			3RCa
Eucalyptus imlayensis	E	e	
Eucalyptus latiuscula			3RC-
Eucalyptus olsenii			2RC-t
Eucalyptus paliformis			2RCat
Eucalyptus parvula	V	v	
Eucalyptus spectatrix			2RC-

Table 3. cont.

	Conservation Status		
	Aust.	**NSW**	**ROTAP**
Eucalyptus wilcoxii			2RCat
Genoplesium rhyoliticum	E	e	
Grevillea acanthifolia subsp. *paludosa*	E	e	
Haloragodendron baeuerlenii			3RCa
Haloragodendron monospermum			3RC-
Hibbertia hermanniifolia			3RCa
Lepidium hyssopifolium	E	e	
Monotoca rotundifolia		e	
Myoporum bateae			3RC-
Persoonia brevifolia			2RCa
Phebalium carruthersii			3RC-
Phebalium ellipticum			2RCa
Phebalium ralstonii	V	v	
Phebalium rhytidophyllum	V	v	
Pomaderris brogoensis			3RC-
Pomaderris costata			3RC-
Pomaderris cotoneaster	E	e	
Pomaderris elachophylla		e	
Pomaderris pallida	V	v	
Pomaderris parrisiae	V	v	
Pomaderris pauciflora			3RC-
Pomaderris virgata			3RC-
Prasophyllum affine	E	e	
Prostanthera walteri			3RCa
Pseudanthus divaricatissimus			3RCa
Pseudanthus ovalifolius		e	
Pultenaea parrisiae subsp. *parrisiae*	V	v	
Pultenaea pedunculata			
Rulingia hermanniifolia			3RCa
Rutidosis leiolepis	V	v	
Senecio spathulatus		e	
Senecio squarrosus		e	
Spyridium cinereum			3RCa
Styphelia psiloclada			3RC-
Thesium australe	V	v	
Viola cleistogamoides		e	
Westringia davidii	V	v	
Westringia kydrensis	E	e	
Zieria sp. D (*citriodora* ms)	V	v	
Zieria sp. G (*buxijugum* ms)	E	e	
Zieria sp. H (*formosa* ms)	E	e	
Zieria sp. I (*parrisiae* ms)	E	e	

Table 4: Number of taxa meeting conservation criteria. Refer to Table 1 for explanations of criteria (note some taxa meet multiple criteria).

Conservation criterion	Number of taxa meeting criterion
1. Regionally endemic	18
2. Threatened in Australia or NSW	38
3. Rare or uncommon throughout distribution	77
4. Restricted distribution outside region	14
5. Regionally uncommon	466
5X. Presumed regionally extinct	7
6. Depleted in the wild	18
7. Distributional limit	276
[northern limit 56]	
[southern limit 201]	
[local northern limit 12]	
[local southern limit 7]	
8. Disjunct population	50
9. Atypical habitat	9

The confirmed indigenous flora included seven species that have not been recorded for 50 or more years, despite recent survey effort and thus may now be extinct within the region. These were *Deschampsia caespitosa* last recorded at Nimmitabel in 1896, *Callitris muelleri* last recorded in 1901, *Acacia paradoxa* last recorded near Eden in 1913, *Eryngium rostratum* last recorded at Bombala in 1914, *Sebaea ovata* last recorded at Mt Imlay in 1916, *Ammobium alatum* last recorded near Bega and Cobargo c. 1920 and *Trochocarpa laurina* last recorded in 1952.

Eighteen taxa were endemic to the Eden region (Category 1, Table 4), while a further 14 taxa were largely restricted to the Eden region (Category 4, Table 4). Two hundred and seventy-six taxa reached their limit of distribution within the Eden region (Category 7, Table 4), including 201 southern limits and 56 northern limits. As noted elsewhere, this disparity suggests latitudinal species turnover and a trend of decreasing diversity with latitude (Keith 1990). For 19 taxa reaching local distributional limits, the Eden region was on the edge of major disjunctions in their range. A further 50 taxa were recorded from locations in the Eden region that were disjunct from their main area of distribution (Category 8, Table 4), while nine taxa were represented in habitats that were not typical of the majority of their distribution (Category 9, Table 4).

Introduced flora

A total of 374 introduced taxa were recorded for the region, although a relatively high proportion of these were not represented in herbarium collections (Appendix 3). Three taxa (1%) were conifers, 98 (26%) were monocots, 273 (73%) were dicots and there were no introduced pteridophytes recorded. Introduced taxa accounted for 20% of the total

vascular flora of the region (c. 1900 taxa). The frequency distribution of introduced taxa was even more highly skewed than that of indigenous flora, with 83% of introduced taxa recorded in 0.1% of samples or less (Fig. 2b). This pattern may indicate a bias in survey and collection work against likely weed habitats such as wastelands and semi-natural pastures. If so, the available data are likely to underestimate the total introduced flora of the region and it is also likely that numerous unconfirmed introduced taxa will be confirmed with additional collection and survey effort.

The introduced flora was dominated by the families Poaceae (67 taxa), Asteraceae (46 taxa), Fabaceae (38 taxa) and Caryophyllaceae (15 taxa). Almost all of the introduced taxa originated from abroad. However, a small number of taxa indigenous to other parts of Australia are likely to have become naturalised in the region since European settlement. These include four *Acacia* species from drier parts of eastern Australia and one grass from coastal habitats (*Cynodon dactylon*).

The most widespread and frequently recorded introduced taxa were Asteraceous herbs found at low local abundance across large areas of forest. These included *Hypochoeris* radicata (21% of samples), *Cirsium vulgare* (6%) and *Conyza albida* (5%). Of 17 introduced taxa recorded in more than 1% of samples, 15 were herbs (including five in the family Asteraceae), one was a grass (*Paspalum dilatatum*) and one was a shrub (*Rubus ulmifolius*). These species have mechanisms for extensive seed dispersal and an ability to establish in disturbed habitats. Riparian zones in agricultural and urban areas support a diverse introduced flora including woody species such as *Salix* spp. and *Rubus* spp., and herbaceous species in the families Juncaceae and Poaceae.

Conclusions

The confirmed indigenous vascular flora of the Eden region (1522 taxa) is relatively species-rich compared with other regions in tropical, temperate and semi-arid Australia, although these regions are less well-known botanically. However, the proportion of endemism (1%) is comparatively low, with 18 taxa unique to the region and a further 14 taxa with distributions extending just beyond the region. The region includes a moderately large number of rare and threatened plant taxa (Table 3) compared with other Australian regions (Briggs & Leigh 1996). A large number of additional taxa are of regional conservation significance because of distributional limits, disjunct populations, regional rarity or atypical habitat relationships. Introduced taxa make up a large proportion (20%) of the total regional vascular flora, but this may be typical of regions containing both large natural landscapes and modified landscapes.

Species frequencies within the indigenous flora were highly skewed with 74% of the flora represented in less than 1% of survey samples and only three taxa represented in more than 40% of samples. This conforms with patterns established in other regional biotas (Keith 1990). Many of the taxa in the tail of the ranked abundance distributions are likely to be abundant somewhere within their range (Murray et al. 1999). Nonetheless, restriction of such a high proportion of regional diversity to a small

number of locations presents a major challenge for conservation planners and managers charged with maintaining full regional biodiversity.

Despite an exhaustive review of available information, records of 136 indigenous taxa remain to be confirmed or refuted in the region. The large number of records (350 taxa) that were evaluated and refuted emphasise the importance of critical validation when compiling biological inventory data from multiple sources. Errors are most likely to arise from nomenclatural synonymy and other duplications, misidentifications and erroneous locality information.

Acknowledgements

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Appendix 1: Indigenous vascular plant taxa with confirmed occurrences in the Eden region. % Freq. is the percentage of 2906 florisitc samples in which respective taxa were recorded. Columns labelled 1–9 indicates which conservation criteria (see Table 1) were met (+) by each taxon. For criterion 7: N: northern limit; S: southern limit; LN: local northern limit; and LS: local southern limit.

	Freq. (%)	1	2	3	4	5	5X	6	7	8	9
PSILOPSIDA											
Psilotaceae											
Tmesipteris obliqua	0	-	-	-	-	-	-	-	-	-	-
Tmesipteris ovata	0	-	-	-	-	+	-	-	-	-	-
Tmesipteris parva	0.28	-	-	-	-	-	-	-	-	-	-
Tmesipteris truncata	0.14	-	-	+	-	-	-	-	S	-	-
LYCOPSIDA											
Lycopodiaceae											
Huperzia myrtifolia	0	-	-	-	-	+	-	-	-	-	-
Lycopodiella lateralis	0.17	-	-	-	-	-	-	-	-	-	-
Lycopodium deuterodensum	0.65	-	-	-	-	-	-	-	-	-	-
Selaginellaceae											
Selaginella uliginosa	1.14	-	-	-	-	-	-	-	-	-	-
FILICOPSIDA											
Adiantiaceae											
Adiantum aethiopicum	6.85	-	-	-	-	-	-	-	-	-	-
Adiantum formosum	0.86	-	-	-	-	-	-	-	-	-	-
Adiantum hispidulum	0.58	-	-	-	-	-	-	-	-	-	-
Aspleniaceae											
Asplenium australasicum	0.28	-	-	-	-	-	-	-	S	-	-
Asplenium bulbiferum subsp. *gracillimum*	0.21	-	-	-	-	-	-	-	-	-	-
Asplenium flabellifolium	10.05	-	-	-	-	-	-	-	-	-	-
Asplenium flaccidum subsp. *flaccidum*	0.03	-	-	-	-	+	-	-	-	-	-
Asplenium obtusatum	0	-	+	-	-	-	-	-	-	-	-
Asplenium polydon	0	-	-	-	-	+	-	-	-	-	-
Asplenium trichomanes subsp. *quadrivalens*	0.03	-	-	-	-	+	-	-	-	-	-
Pleurosorus rutifolius	0	-	-	-	-	+	-	-	-	-	-
Athryriaceae											
Diplazium australe	0.14	-	-	-	-	-	-	-	-	-	-
Azollaceae											
Azolla pinnata	0	-	-	-	-	-	-	-	-	-	-
Blechnaceae											
Blechnum cartilagineum	9.84	-	-	-	-	-	-	-	-	-	-
Blechnum minus	0.86	-	-	-	-	-	-	-	-	-	-
Blechnum nudum	6.30	-	-	-	-	-	-	-	-	-	-
Blechnum patersonii subsp. *patersonii*	0.96	-	-	-	-	-	-	-	-	-	-
Blechnum penna-marina subsp. *alpina*	0.03	-	-	-	-	-	-	+	-	-	-
Blechnum wattsii	3.34	-	-	-	-	-	-	-	-	-	-
Doodia aspera	10.53	-	-	-	-	-	-	-	-	-	-
Doodia caudata var. *caudata*	0.14	-	-	-	-	-	-	-	-	-	-
Doodia media subsp. *media*	0.07	-	-	-	-	+	-	-	-	-	-

Appendix 1 cont.	Freq. (%)	1	2	3	4	5	5X	6	7	8	9
Cyatheaceae											
Cyathea australis	9.39	-	-	-	-	-	-	-	-	-	-
Cyathea leichhardtiana	0.17	-	-	-	-	+	-	-	-	-	-
Davalliaceae											
Arthropteris tenella	0.03	-	-	-	-	+	-	-	S	-	-
Davallia pyxidata	0.07	-	-	-	-	+	-	-	LS	-	
Rumohra adiantiformis	0.21	-	-	-	-	-	-	-	-	-	-
Dennstaedtiaceae											
Dennstaedtia davallioides	0.48	-	-	-	-	-	-	-	-	-	-
Histiopteris incisa	1.27	-	-	-	-	-	-	-	-	-	-
Hypolepis glandulifera	1.10	-	-	-	-	-	-	-	-	-	-
Hypolepis muelleri	0.69	-	-	-	-	-	-	-	-	-	-
Pteridium esculentum	49.93	-	-	-	-	-	-	-	-	-	-
Dicksoniaceae											
Calochlaena dubia	9.39	-	-	-	-	-	-	-	-	-	-
Dicksonia antarctica	4.61	-	-	-	-	-	-	-	-	-	-
Dryopteridaceae											
Lastreopsis acuminata	0.72	-	-	-	-	-	-	-	-	-	-
Lastreopsis decomposita	0.79	-	-	-	-	-	-	-	-	-	-
Lastreopsis microsora	1.58	-	-	-	-	-	-	-	-	-	-
Polystichum formosum	0	-	-	-	-	+	-	-	-	+	-
Polystichum proliferum	6.23	-	-	-	-	-	-	-	-	-	-
Gleicheniaceae											
Gleichenia dicarpa	0.55	-	-	-	-	-	-	-	-	-	-
Gleichenia microphylla	0.31	-	-	-	-	-	-	-	-	-	-
Gleichenia rupestris	0	-	-	-	-	+	-	-	S	-	-
Sticherus flabellatus	0.07	-	-	-	-	-	-	-	-	-	-
Sticherus lobatus	1.07	-	-	-	-	-	-	-	-	-	-
Sticherus tener	0	-	-	-	-	+	-	-	-	-	-
Grammitaceae											
Grammitis billardieri	0.17	-	-	-	-	-	-	-	-	-	-
Hymenophyllaceae											
Hymenophyllum cupressiforme	0.86	-	-	-	-	-	-	-	-	-	-
Hymenophyllum flabellatum	0.17	-	-	-	-	-	-	-	-	-	-
Macroglena caudata	0.03	-	-	-	-	+	-	-	-	-	-
Polyphlebium venosum	0.34	-	-	-	-	-	-	-	-	-	-
Lindsaeaceae											
Lindsaea linearis	2.86	-	-	-	-	-	-	-	-	-	-
Lindsaea microphylla	2.27	-	-	-	-	-	-	-	-	-	-
Marsileaceae											
Marsillea costulifera	0	-	-	-	-	+	-	-	-	-	-
Marsillea hirsuta	0	-	-	-	-	+	-	-	-	-	-
Ophioglossaceae											
Botrychium australe	0.28	-	-	+	-	-	-	-	-	-	-
Ophioglossum lusitanicum subsp. *coriacium*	0	-	-	-	-	+	-	-	-	-	-
Osmundaceae											
Todea barbara	0.52	-	-	-	-	-	-	-	-	-	-
Polypodiaceae											
Microsorum pustulatum	1.27	-	-	-	-	-	-	-	-	-	-
Microsorum scandens	0.96	-	-	-	-	-	-	-	-	-	-

Appendix 1 cont.	**Freq. (%)**	**1**	**2**	**3**	**4**	**5**	**5X**	**6**	**7**	**8**	**9**
Polypodiaceae cont.											
Platycerium bifurcatum subsp. *bifurcatum*	0.07	-	-	-	-	+	-	-	S	-	-
Pyrrosia rupestris	2.34	-	-	-	-	-	-	-	-	-	-
Pteridaceae											
Pteris tremula	1.38	-	-	-	-	-	-	-	-	-	-
Pteris umbrosa	0.93	-	-	-	-	-	-	-	-	-	-
Pteris sp. aff. *comans*	0.17	-	-	-	-	+	-	-	-	+	-
Schizaeaceae											
Schizaea asperula	0.17	-	-	-	-	-	-	-	-	-	-
Schizaea bifida	0.24	-	-	-	-	-	-	-	-	-	-
Sinopteridaceae											
Cheilanthes austrotenuifolia	0.69	-	-	-	-	-	-	-	-	-	-
Cheilanthes distans	0.21	-	-	-	-	-	-	-	-	-	-
Cheilanthes sieberi subsp. *sieberi*	4.13	-	-	-	-	-	-	-	-	-	-
Pellaea falcata var. *falcata*	8.26	-	-	-	-	-	-	-	-	-	-
Pellaea falcata var. *nana*	0.14	-	-	-	-	+	-	-	-	-	-
CONIFEROPSIDA											
Cupressaceae											
Callitris endlicheri	0.24	-	-	-	-	-	-	-	-	-	-
Callitris muelleri	0	-	-	-	-	+	+	-	S	+	-
Callitris rhomboidea	0.24	-	-	-	-	-	-	-	-	-	-
Podocarpaceae											
Podocarpus spinulosus	0	-	-	-	-	+	-	-	S	+	-
CYCADOPSIDA											
Zamiaceae											
Macrozamia communis	4.51	-	-	-	-	-	-	-	S	-	-
MAGNOLIOPSIDA (LILIIDAE)											
Alismataceae											
Alisma plantago-aquatica	0.03	-	-	-	-	-	-	-	-	-	-
Anthericaceae											
Arthropodium milleflorum	3.79	-	-	-	-	-	-	-	-	-	-
Arthropodium minus	1.69	-	-	-	-	-	-	-	-	-	-
Caesia calliantha	0	-	-	-	-	+	-	-	-	-	-
Caesia parviflora var. *parviflora*	0.24	-	-	-	-	-	-	-	-	-	-
Caesia parviflora var. *vittata*	0.21	-	-	-	-	-	-	-	-	-	-
Dichopogon fimbriatus	0	-	-	-	-	+	-	-	-	-	-
Laxmannia gracilis	0.10	-	-	-	-	+	-	-	-	-	-
Sowerbaea juncea	0.21	-	-	-	-	-	-	-	-	-	-
Thysanotus juncifolius	0.03	-	-	-	-	+	-	-	-	-	-
Thysanotus patersonii	0	-	-	-	-	+	-	-	-	-	+
Thysanotus tuberosus	1.31	-	-	-	-	-	-	-	-	-	-
Tricoryne elatior	0.24	-	-	-	-	-	-	-	-	-	-
Arecaceae											
Livistona australis	0.07	-	-	-	-	+	-	-	-	-	-
Asphodelaceae											
Bulbine bulbosa	0.07	-	-	-	-	-	-	+	-	-	-
Bulbine glauca	0	-	-	-	-	+	-	-	-	-	-
Bulbine semibarbata	0.10	-	-	-	-	-	-	-	-	-	-

Appendix 1 cont.	**Freq. (%)**	**1**	**2**	**3**	**4**	**5**	**5X**	**6**	**7**	**8**	**9**
Centrolepidaceae											
Centrolepis aristata	0	-	-	-	-	+	-	-	-	-	-
Centrolepis fascicularis	0.10	-	-	-	-	+	-	-	-	-	-
Centrolepis strigosa subsp. *strigosa*	0.21	-	-	-	-	-	-	-	-	-	-
Colchicaceae											
Burchardia umbellata	1.38	-	-	-	-	-	-	-	-	-	-
Wurmbea biglandulosa	0	-	-	-	-	+	-	-	-	-	-
Wurmbea dioica	0.14	-	-	-	-	-	-	-	-	-	-
Commelinaceae											
Aneilema biflorum	0.03	-	-	-	-	+	-	-	S	-	-
Commelina cyanea	2.79	-	-	-	-	-	-	-	S	-	-
Cyperaceae											
Baumea acuta	0.03	-	-	-	-	+	-	-	-	-	-
Baumea articulata	0	-	-	-	-	+	-	-	-	-	-
Baumea gunnii	0.03	-	-	-	-	-	-	-	-	-	-
Baumea juncea	0.89	-	-	-	-	-	-	-	-	-	-
Baumea rubiginosa	0.58	-	-	-	-	-	-	-	-	-	-
Baumea teretifolia	0.07	-	-	-	-	+	-	-	-	-	-
Baumea tetragona	0.24	-	-	-	-	-	-	-	-	-	-
Carex appressa	5.47	-	-	-	-	-	-	-	-	-	-
Carex bichenoviana	0	-	-	-	-	+	-	-	-	-	-
Carex breviculmis	4.78	-	-	-	-	-	-	-	-	-	-
Carex brownii	0.07	-	-	-	-	+	-	-	-	-	-
Carex capillacea	0.03	-	-	+	-	-	-	-	-	-	-
Carex declinata	0	-	-	-	-	+	-	-	S	+	-
Carex fascicularis	0.03	-	-	-	-	+	-	-	-	-	-
Carex gaudichaudiana	0.58	-	-	-	-	-	-	-	-	-	-
Carex inversa	1.93	-	-	-	-	-	-	-	-	-	-
Carex longebrachiata	2.10	-	-	-	-	-	-	-	-	-	-
Carex polyantha	0.03	-	-	-	-	+	-	-	-	-	-
Carex pumila	0.34	-	-	-	-	-	-	-	-	-	-
Carex tereticaulis	0	-	-	-	-	+	-	-	-	-	-
Caustis flexuosa	2.27	-	-	-	-	-	-	-	-	-	-
Caustis pentandra	0.31	-	-	-	-	-	-	-	-	-	-
Caustis recurvata var. *recurvata*	0	-	-	-	-	+	-	-	S	-	-
Cyathochaeta diandra	0.45	-	-	-	-	-	-	-	-	-	-
Cyperus brevifolius	0	-	-	-	-	+	-	-	-	-	-
Cyperus gracilis	0.17	-	-	-	-	-	-	-	-	-	-
Cyperus gunnii subsp. *gunnii*	0	-	-	-	-	+	-	-	-	-	-
Cyperus imbecillis	0.03	-	-	-	-	+	-	-	S	-	-
Cyperus laevigatus	0.03	-	-	-	-	+	-	-	S	-	-
Cyperus lhotskyanus	0	-	-	-	-	+	-	-	-	-	-
Cyperus lucidus	0.96	-	-	-	-	-	-	-	-	-	-
Cyperus sanguinolentus	0.07	-	-	-	-	+	-	-	-	-	-
Cyperus sphaeroideus	0.07	-	-	-	-	+	-	-	-	-	-
Eleocharis acuta	0.03	-	-	-	-	-	-	-	-	-	-
Eleocharis gracilis	0.48	-	-	-	-	-	-	-	-	-	-
Eleocharis sphacelata	0.10	-	-	-	-	-	-	-	-	-	-
Gahnia aspera	1.27	-	-	-	-	-	-	-	S	-	-
Gahnia clarkei	0.21	-	-	-	-	-	-	-	-	-	-
Gahnia filum	0.52	-	-	-	-	-	-	-	-	-	-
Gahnia melanocarpa	7.98	-	-	-	-	-	-	-	-	-	-
Gahnia microstachya	0.31	-	-	-	-	-	-	-	-	-	-

Appendix 1 cont.	**Freq. (%)**	**1**	**2**	**3**	**4**	**5**	**5X**	**6**	**7**	**8**	**9**
Cyperaceae cont.											
Gahnia radula	8.50	-	-	-	-	-	-	-	-	-	-
Gahnia sieberiana	5.54	-	-	-	-	-	-	-	-	-	-
Gahnia subaequiglumis	0.24	-	-	-	-	+	-	-	-	-	-
Gymnoschoenus sphaerocephalus	0.38	-	-	-	-	-	-	-	-	-	-
Isolepis aucklandica	0.03	-	-	-	-	+	-	-	-	-	-
Isolepis cernua	0.10	-	-	-	-	-	-	-	-	-	-
Isolepis crassiuscula	0	-	-	-	-	+	-	-	-	-	-
Isolepis habra	0.65	-	-	-	-	-	-	-	-	-	-
Isolepis inundata	1.31	-	-	-	-	-	-	-	-	-	-
Isolepis nodosa	2.06	-	-	-	-	-	-	-	-	-	-
Isolepis platycarpa	0	-	-	-	-	+	-	-	-	-	-
Isolepis producta	0	-	-	-	-	+	-	-	-	-	-
Isolepis subtilissima	0.28	-	-	-	-	-	-	-	-	-	-
Lepidosperma concavum	0.31	-	-	-	-	-	-	-	-	-	-
Lepidosperma curtisiae	0	-	-	-	-	+	-	-	-	-	-
Lepidosperma elatius	0.10	-	-	-	-	-	-	-	-	-	-
Lepidosperma filiforme	1.14	-	-	-	-	+	-	-	-	-	-
Lepidosperma forsythii	0.31	-	-	-	-	+	-	-	-	-	-
Lepidosperma gladiatum	0.34	-	-	-	-	-	-	-	-	-	-
Lepidosperma gunnii	1.45	-	-	-	-	-	-	-	-	-	-
Lepidosperma latens	0	-	-	-	-	+	-	-	S	+	-
Lepidosperma laterale	34.96	-	-	-	-	-	-	-	-	-	-
Lepidosperma limicola	0.28	-	-	-	-	-	-	-	-	-	-
Lepidosperma longitudinale	0	-	-	-	-	+	-	-	-	-	-
Lepidosperma neesii	0.86	-	-	-	-	-	-	-	-	-	-
Lepidosperma semiteres	0.03	-	-	-	-	+	-	-	LN	-	-
Lepidosperma tortuosum	0.62	-	-	-	-	-	-	-	-	-	-
Lepidosperma urophorum	8.40	-	-	-	-	-	-	-	-	-	-
Ptilothrix deusta	0.07	-	-	-	-	+	-	-	S	-	-
Schoenoplectus mucronatus	0	-	-	-	-	+	-	-	S	+	-
Schoenoplectus validus	0	-	-	-	-	-	-	-	-	-	-
Schoenus apogon	1.51	-	-	-	-	-	-	-	-	-	-
Schoenus brevifolius	0.72	-	-	-	-	-	-	-	-	-	-
Schoenus ericetorum	0.07	-	-	-	-	+	-	-	-	-	-
Schoenus imberbis	0.14	-	-	-	-	-	-	-	-	-	-
Schoenus lepidosperma subsp. *lepidosperma*	0.28	-	-	-	-	-	-	-	-	-	-
Schoenus lepidosperma subsp. *pachylepis*	0.14	-	-	-	-	-	-	-	S	-	-
Schoenus maschalinus	0.38	-	-	-	-	-	-	-	-	-	-
Schoenus melanostachys	0.62	-	-	-	-	-	-	-	-	-	-
Schoenus moorei	0.07	-	-	-	-	+	-	-	S	-	-
Schoenus nitens	0.07	-	-	-	-	+	-	-	-	-	-
Schoenus turbinatus	0	-	-	-	-	+	-	-	-	-	-
Schoenus villosus	0.03	-	-	-	-	+	-	-	S	+	-
Scirpus polystachyus	0	-	-	-	-	+	-	-	-	-	-
Scleria mackaviensis	0.10	-	-	-	-	+	-	-	S	+	-
Tetraria capillaris	0.17	-	-	-	-	-	-	-	-	-	-
Tricostularia pauciflora	0	-	-	-	-	+	-	-	-	-	-
Uncinia nemoralis	0	-	-	-	-	+	-	-	-	-	-
Uncinia tenella	0.03	-	-	-	-	+	-	-	-	-	-
Haemodoraceae											
Haemodorum planifolium	0	-	-	-	-	+	-	-	S	-	-

Appendix 1 cont.	**Freq. (%)**	**1**	**2**	**3**	**4**	**5**	**5X**	**6**	**7**	**8**	**9**
Hydrocharitaceae											
Halophila ovalis	0	-	-	-	-	-	-	-	-	-	-
Ottelia ovalifolia	0	-	-	-	-	+	-	-	-	-	-
Vallisneria gigantea	0.03	-	-	-	-	-	-	-	-	-	-
Hypoxidaceae											
Hypoxis hygrometrica var. *hygrometrica*	0.41	-	-	-	-	-	-	-	-	-	-
Hypoxis hygrometrica var. *villosisepala*	0.41	-	-	-	-	-	-	-	-	-	-
Iridaceae											
Diplarrena moraea	0.96	-	-	-	-	-	-	-	-	-	-
Libertia paniculata	1.27	-	-	-	-	-	-	-	-	-	-
Patersonia fragilis	1.48	-	-	-	-	-	-	-	-	-	-
Patersonia glabrata	4.71	-	-	-	-	-	-	-	-	-	-
Patersonia longifolia	0.52	-	-	-	-	-	-	-	-	-	-
Patersonia sericea	1.20	-	-	-	-	-	-	-	-	-	-
Patersonia sp. aff. *fragilis*	0.21	-	-	-	-	-	-	-	-	-	-
Juncaceae											
Juncus alexandri subsp. *alexandri*	0.10	-	-	-	-	-	-	-	-	-	-
Juncus australis	0.34	-	-	-	-	-	-	-	-	-	-
Juncus continuus	0.52	-	-	-	-	-	-	-	-	-	-
Juncus falcatus	0.10	-	-	-	-	-	-	-	-	-	-
Juncus filicaulis	0.10	-	-	-	-	-	-	-	-	-	-
Juncus fockei	0.17	-	-	-	-	-	-	-	-	-	-
Juncus gregiflorus	0.17	-	-	-	-	-	-	-	-	-	-
Juncus homalocaulis	0.03	-	-	-	-	-	-	-	-	-	-
Juncus kraussii subsp. *australiensis*	2.41	-	-	-	-	-	-	-	-	-	-
Juncus pallidus	0.14	-	-	-	-	-	-	-	-	-	-
Juncus pauciflorus	0.58	-	-	-	-	-	-	-	-	-	-
Juncus phaeanthus	0.03	-	-	-	-	-	-	-	-	-	-
Juncus planifolius	1.07	-	-	-	-	-	-	-	-	-	-
Juncus prismatocarpus	0	-	-	-	-	-	-	-	-	-	-
Juncus procerus	0	-	-	-	-	-	-	-	-	-	-
Juncus sandwithii	0.03	-	-	-	-	+	-	-	-	-	-
Juncus sarophorus	0.17	-	-	-	-	-	-	-	-	-	-
Juncus subsecundus	0.28	-	-	-	-	-	-	-	-	-	-
Juncus usitatus	0.69	-	-	-	-	-	-	-	-	-	-
Juncus vaginatus	0.07	-	-	-	-	-	-	-	-	-	-
Luzula densiflora	0.14	-	-	-	-	-	-	-	-	-	-
Luzula flaccida	5.82	-	-	-	-	-	-	-	-	-	-
Luzula meridionalis	0.72	-	-	-	-	-	-	-	-	-	-
Luzula modesta	0	-	-	-	-	+	-	-	-	-	-
Luzula ovata	0.34	-	-	-	-	-	-	-	-	-	-
Juncaginaceae											
Triglochin microtuberosum	0	-	-	-	-	-	-	-	-	-	-
Triglochin procerum	0	-	-	-	-	-	-	-	-	-	-
Triglochin rheophilum	0	-	-	-	-	-	-	-	-	-	-
Triglochin striata	0.52	-	-	-	-	-	-	-	-	-	-
Lomandraceae											
Lomandra confertifolia subsp. *leptostachya*	1.62	-	-	-	-	-	-	-	-	-	-
Lomandra confertifolia subsp. *rubiginosa*	2.31	-	-	-	-	-	-	-	S	-	-
Lomandra confertifolia subsp. *similis*	3.17	-	-	-	-	-	-	-	S	-	-
Lomandra cylindrica	0.28	-	-	-	-	-	-	-	-	-	-
Lomandra filiformis subsp. *coriacea*	1.58	-	-	-	-	-	-	-	-	-	-

Appendix 1 cont.	**Freq. (%)**	**1**	**2**	**3**	**4**	**5**	**5X**	**6**	**7**	**8**	**9**
Lomandraceae cont.											
Lomandra filiformis subsp. *filiformis*	5.99	-	-	-	-	-	-	-	-	-	-
Lomandra filiformis subsp. *flavior*	0.96	-	-	-	-	-	-	-	-	-	-
Lomandra glauca	4.96	-	-	-	-	-	-	-	-	-	-
Lomandra longifolia subsp. *exilis*	0.96	-	-	-	-	-	-	-	-	-	-
Lomandra longifolia subsp. *longifolia*	50.17	-	-	-	-	-	-	-	-	-	-
Lomandra multiflora subsp. *multiflora*	23.71	-	-	-	-	-	-	-	-	-	-
Luzuriagaceae											
Drymophila cyanocarpa	1.27	-	-	-	-	-	-	-	-	-	-
Eustrephus latifolius	16.00	-	-	-	-	-	-	-	-	-	-
Geitonoplesium cymosum	11.80	-	-	-	-	-	-	-	-	-	-
Orchidaceae											
Acianthus caudatus	0	-	-	-	-	-	-	-	-	-	-
Acianthus exsertus	0.38	-	-	-	-	-	-	-	-	-	-
Acianthus fornicatus	0	-	-	-	-	-	-	-	S	-	-
Acianthus pusillus	0	-	-	-	-	-	-	-	-	-	-
Arthrochilus huntianus	0	-	-	-	-	-	-	-	-	-	-
Burnettia cuneata	0	-	-	+	-	-	-	-	-	+	-
Caladenia caerulea	0	-	-	-	-	-	-	-	-	-	-
Caladenia carnea var. *carnea*	0.10	-	-	-	-	-	-	-	-	-	-
Caladenia catenata	0.45	-	-	-	-	-	-	-	-	-	-
Caladenia clarkiae	0	-	-	+	-	-	-	-	-	-	-
Caladenia congesta	0	-	-	-	-	+	-	-	-	-	-
Caladenia deformis	0	-	-	-	-	+	-	-	-	-	-
Caladenia gracilis	0	-	-	-	-	+	-	-	-	-	-
Caladenia hildae	0	-	-	-	-	+	-	-	-	-	-
Caladenia picta	0	-	-	-	-	+	-	-	-	-	-
Caladenia pusilla	0	-	-	+	-	-	-	-	-	-	-
Caladenia testacea	0	-	-	-	-	+	-	-	-	-	-
Caladenia tesselata	0	-	+	-	-	-	-	-	-	-	-
Caladenia sp. aff. *reticulata*	0	-	-	+	+	-	-	-	N	-	-
Caleana major	0.10	-	-	-	-	-	-	-	-	-	-
Caleana minor	0	-	-	-	-	-	-	-	-	-	-
Calochilus campestris	0.03	-	-	-	-	-	-	-	-	-	-
Calochilus gracillimus	0	-	-	-	-	+	-	-	-	-	-
Calochilus paludosus	0	-	-	-	-	-	-	-	-	-	-
Calochilus robertsonii	0.10	-	-	-	-	-	-	-	-	-	-
Chiloglottis pluricallata	0.14	-	-	-	-	-	-	-	S	-	-
Chiloglottis reflexa	0.07	-	-	-	-	-	-	-	-	-	-
Chiloglottis turfosa	0	-	-	-	-	-	-	-	-	-	-
Corybas aconitiflorus	0	-	-	-	-	+	-	-	-	-	-
Corybas fimbriatus	0	-	-	-	-	-	-	-	-	-	-
Corybas fordhamii	0	-	-	-	-	+	-	-	-	-	-
Corybas unguiculatus	0	-	-	-	-	-	-	-	-	-	-
Cryptostylis erecta	0.03	-	-	-	-	+	-	-	-	-	-
Cryptostylis hunteriana	0	-	+	-	-	-	-	-	-	-	-
Cryptostylis leptochila	0.14	-	-	-	-	-	-	-	-	-	-
Cryptostylis subulata	0.28	-	-	-	-	-	-	-	-	-	-
Cymbidium suave	0.93	-	-	-	-	-	-	-	S	-	-
Cyrtostylis reniformis	0	-	-	-	-	-	-	-	-	-	-
Dendrobium aemulum	0	-	-	-	-	+	-	-	S	-	-
Dendrobium pugioniforme	0.07	-	-	-	-	+	-	-	S	-	-
Dendrobium speciosum	1.62	-	-	-	-	-	-	-	-	-	-

Appendix 1 cont.	**Freq. (%)**	**1**	**2**	**3**	**4**	**5**	**5X**	**6**	**7**	**8**	**9**
Orchidaceae cont.											
Dendrobium striolatum	1.03	-	-	-	-	-	-	-	-	-	-
Dipodium punctatum	1.51	-	-	-	-	-	-	-	-	-	-
Dipodium roseum	0	-	-	-	-	-	-	-	-	-	-
Diuris corymbosa	0	-	-	-	-	+	-	-	N	-	-
Diuris lanceolata	0	-	-	-	-	-	-	-	-	-	-
Diuris ochroma	0	-	+	-	-	-	-	-	-	-	-
Diuris pardina	0.03	-	-	-	-	-	-	-	-	-	-
Diuris pedunculata	0	-	+	-	-	-	-	-	-	-	-
Diuris punctata var. *punctata*	0	-	-	-	-	-	-	-	-	-	-
Diuris sulphurea	0.10	-	-	-	-	-	-	-	-	-	-
Eriochilus cucullatus	0.21	-	-	-	-	-	-	-	-	-	-
Gastrodia sesamoides	0	-	-	-	-	-	-	-	-	-	-
Genoplesium archeri	0	-	-	-	-	-	-	-	-	-	-
Genoplesium nudiscapum	0	-	-	-	-	+	-	-	-	-	-
Genoplesium nudum	0	-	-	-	-	-	-	-	-	-	-
Genoplesium rhyoliticum	0.03	+	+	-	-	-	-	-	-	-	-
Glossodia major	0.21	-	-	-	-	-	-	-	-	-	-
Glossodia minor	0	-	-	-	-	-	-	-	-	-	-
Liparis reflexa	0.03	-	-	-	-	+	-	-	S	-	-
Lyperanthus nigricans	0	-	-	-	-	-	-	-	-	-	-
Lyperanthus suaveolens	0	-	-	-	-	+	-	-	-	-	-
Microtis parviflora	0.03	-	-	-	-	-	-	-	-	-	-
Microtis rara	0	-	-	-	-	+	-	-	-	-	-
Microtis unifolia	0	-	-	-	-	-	-	-	-	-	-
Orthoceras strictum	0	-	-	-	-	+	-	-	-	-	-
Plectorrhiza tridentata	0.10	-	-	-	-	-	-	-	-	-	-
Prasophyllum affine	0	-	+	-	-	-	-	-	-	-	-
Prasophyllum appendiculatum	0	-	-	-	-	+	-	-	-	-	-
Prasophyllum brevilabre	0	-	-	-	-	-	-	-	-	-	-
Prasophyllum elatum	0	-	-	-	-	-	-	-	-	-	-
Prasophyllum flavum	0	-	-	+	-	-	-	-	-	-	-
Prasophyllum sp. aff. *fitzgeraldii*	0	-	-	-	-	+	-	-	-	-	-
Pterostylis alata	0	-	-	-	-	+	-	-	-	-	-
Pterostylis alpina	0	-	-	-	-	+	-	-	-	-	-
Pterostylis concinna	0	-	-	-	-	-	-	-	-	-	-
Pterostylis curta	0	-	-	-	-	-	-	-	-	-	-
Pterostylis decurva	0.14	-	-	-	-	-	-	-	-	-	-
Pterostylis furcata	0	-	-	-	-	+	-	-	-	-	-
Pterostylis longifolia	0.24	-	-	-	-	-	-	-	-	-	-
Pterostylis nutans	0.10	-	-	-	-	-	-	-	-	-	-
Pterostylis obtusa	0.03	-	-	-	-	+	-	-	-	-	-
Pterostylis parviflora	0.21	-	-	-	-	-	-	-	-	-	-
Pterostylis pedoglossa	0	-	-	-	-	+	-	-	-	-	-
Pterostylis pedunculata	0	-	-	-	-	-	-	-	-	-	-
Pterostylis plumosa	0	-	-	-	-	+	-	-	-	+	+
Pterostylis reflexa	0	-	-	-	-	+	-	-	S	-	-
Pterostylis revoluta	0	-	-	-	-	+	-	-	-	-	-
Pterostylis sp. aff. *rufa*	0	-	-	-	-	+	-	-	-	-	-
Sarcochilus australis	0.03	-	-	-	-	-	-	+	-	-	-
Sarcochilus falcatus	0.14	-	-	-	-	-	-	-	-	-	-
Sarcochilus hillii	0.03	-	-	-	-	+	-	+	S	-	-
Sarcochilus olivaceus	0	-	-	-	-	+	-	+	S	-	-
Spiranthes sinensis subsp. *australis*	0	-	-	-	-	-	-	-	-	-	-

Appendix 1 cont.	**Freq. (%)**	**1**	**2**	**3**	**4**	**5**	**5X**	**6**	**7**	**8**	**9**
Orchidaceae cont.											
Thelymitra carnea	0	-	-	-	-	-	-	-	-	-	-
Thelymitra cyanea	0.03	-	-	-	-	+	-	-	-	-	-
Thelymitra ixioides var. *ixioides*	0	-	-	-	-	-	-	-	-	-	-
Thelymitra media var. *media*	0	-	-	-	-	-	-	-	-	-	-
Thelymitra nuda	0	-	-	-	-	+	-	-	-	-	-
Thelymitra pauciflora	0.34	-	-	-	-	-	-	-	-	-	-
Phormiaceae											
Dianella caerulea	28.77	-	-	-	-	-	-	-	-	-	-
Dianella congesta	0	-	-	-	-	+	-	-	S	-	-
Dianella longifolia var. *longifolia*	0.86	-	-	-	-	-	-	-	-	-	-
Dianella revoluta var. *revoluta*	6.78	-	-	-	-	-	-	-	-	-	-
Dianella tasmanica	16.38	-	-	-	-	-	-	-	-	-	-
Stypandra glauca	2.75	-	-	-	-	-	-	-	-	-	-
Thelionema caespitosum	0.65	-	-	-	-	-	-	-	-	-	-
Thelionema umbellatum	0.10	-	-	-	-	+	-	-	-	-	-
Phylidraceae											
Philydrum lanuginosum	0	-	-	-	-	+	-	-	-	-	-
Poaceae											
Agrostis aemula	0	-	-	-	-	+	-	-	-	-	-
Agrostis avenacea var. *avenacea*	1.55	-	-	-	-	-	-	-	-	-	-
Agrostis billardieri	0.07	-	-	-	-	+	-	-	-	-	-
Agrostis sp. aff. *hiemalis*	0	-	-	-	-	+	-	-	-	-	-
Amphibromus nervosus	0	-	-	-	-	+	-	-	-	-	-
Amphipogon strictus var. *strictus*	0.03	-	-	-	-	+	-	-	-	-	-
Anisopogon avenaceus	1.89	-	-	-	-	-	-	-	-	-	-
Aristida jerichoensis var. *jerichoensis*	0	-	-	-	-	+	-	-	S	-	-
Aristida ramosa var. *ramosa*	0.38	-	-	-	-	-	-	-	-	-	-
Aristida vagans	1.51	-	-	-	-	-	-	-	S	-	-
Australopyrum pectinatum	0.03	-	-	-	-	+	-	-	-	-	-
Australopyrum retrofractum	0	-	-	-	-	-	-	-	-	-	-
Austrofestuca eriopoda	0	-	-	-	-	+	-	-	-	-	-
Austrofestuca hookeriana	0.03	-	-	-	-	+	-	-	-	-	-
Austrofestuca littoralis	0.86	-	-	-	-	-	-	-	-	-	-
Austrostipa bigeniculata	0	-	-	-	-	-	-	-	-	-	-
Austrostipa blackii	0.03	-	-	-	-	+	-	-	-	-	-
Austrostipa densiflora	0.03	-	-	-	-	-	-	-	-	-	-
Austrostipa flavescens	0.24	-	-	-	-	-	-	-	-	-	-
Austrostipa mollis	0.03	-	-	-	-	-	-	-	-	-	-
Austrostipa nivicola	0	-	-	-	-	+	-	-	-	-	-
Austrostipa nodosa	0	-	-	-	-	+	-	-	-	-	-
Austrostipa pubescens	0.07	-	-	-	-	-	-	-	S	-	-
Austrostipa pubinodis	0.76	-	-	-	-	-	-	-	-	-	-
Austrostipa ramosissima	0.07	-	-	-	-	-	-	-	S	-	-
Austrostipa rudis subsp. *australis*	0	-	-	-	-	+	-	-	N	-	-
Austrostipa rudis subsp. *nervosa*	4.20	-	-	-	-	-	-	-	-	-	-
Austrostipa rudis subsp. *rudis*	0.24	-	-	-	-	-	-	-	-	-	-
Austrostipa scabra subsp. *falcata*	0.03	-	-	-	-	-	-	-	-	-	-
Austrostipa semibarbata	0.10	-	-	-	-	+	-	-	-	-	-
Austrostipa stipoides	1.20	-	-	-	-	-	-	-	-	-	-
Austrostipa stuposa	0	-	-	-	-	-	-	-	-	-	-
Austrostipa verticillata	0.03	-	-	-	-	-	-	-	S	-	-
Bothriochloa macra	0.07	-	-	-	-	-	-	-	-	-	-

Appendix 1 cont.	**Freq. (%)**	**1**	**2**	**3**	**4**	**5**	**5X**	**6**	**7**	**8**	**9**
Poaceae cont.											
Cenchrus caliculatus	0.38	-	-	-	-	-	-	-	S	-	-
Chionochloa pallida	11.63	-	-	-	-	-	-	-	-	-	-
Chloris truncata	0	-	-	-	-	-	-	-	-	-	-
Chloris ventricosa	0.03	-	-	-	-	-	-	-	-	-	-
Cymbopogon refractus	1.14	-	-	-	-	-	-	-	-	-	-
Deschampsia caespitosa	0	-	-	-	-	+	+	-	-	-	-
Deyeuxia accedens	0.07	-	-	+	-	-	-	-	N	-	-
Deyeuxia angustifolia	0	-	-	-	-	+	-	-	S	-	-
Deyeuxia brachyathera	0.03	-	-	-	-	+	-	-	-	-	-
Deyeuxia contracta	0.34	-	-	-	-	-	-	-	-	-	-
Deyeuxia crassiuscula	0.14	-	-	-	-	+	-	-	-	-	-
Deyeuxia gunniana	0.31	-	-	-	-	-	-	-	-	-	-
Deyeuxia microseta	0	-	-	+	-	-	-	-	LN	-	-
Deyeuxia monticola var. *monticola*	1.65	-	-	-	-	-	-	-	-	-	-
Deyeuxia nudiflora	0.03	-	-	-	-	+	-	-	-	-	-
Deyeuxia parviseta var. *boormanii*	0.14	-	-	-	-	-	-	-	-	-	-
Deyeuxia parviseta var. *parviseta*	0.14	-	-	-	-	-	-	-	-	-	-
Deyeuxia quadriseta	2.51	-	-	-	-	-	-	-	-	-	-
Deyeuxia scaberula	0.07	-	-	-	-	+	-	-	-	-	-
Deyeuxia sp. aff. *brachyathera*	0	-	-	-	-	+	-	-	-	-	-
Deyeuxia sp. aff. *crassiuscula*	0	-	-	-	-	+	-	-	-	-	-
Deyeuxia talariata	0	-	-	+	+	-	-	-	S	+	-
Dichanthium sericeum subsp. *sericeum*	0.63								S		
Dichelachne crinita	0.55	-	-	-	-	-	-	-	-	-	-
Dichelachne inaequiglumis	0.17	-	-	-	-	-	-	-	-	-	-
Dichelachne micrantha	4.65	-	-	-	-	-	-	-	-	-	-
Dichelachne parva	0.10	-	+	-	-	-	-	-	-	-	-
Dichelachne rara	10.87	-	-	-	-	-	-	-	-	-	-
Dichelachne sieberiana	0	-	-	-	-	+	-	-	-	-	-
Digitaria parviflora	0.69	-	-	-	-	-	-	-	-	-	-
Digitaria ramularis	0.76	-	-	-	-	-	-	-	S	-	-
Dryopoa dives	0	-	-	-	-	-	-	-	-	-	-
Echinopogon caespitosus var. *caespitosus*	2.37	-	-	-	-	-	-	-	-	-	-
Echinopogon mckiei	0	-	-	-	-	+	-	-	-	-	-
Echinopogon ovatus	11.08	-	-	-	-	-	-	-	-	-	-
Elymus scaber var. *scaber*	2.34	-	-	-	-	-	-	-	-	-	-
Enneapogon nigricans	0.03	-	-	-	-	+	-	-	-	-	-
Entolasia marginata	5.68	-	-	-	-	-	-	-	-	-	-
Entolasia stricta	19.48	-	-	-	-	-	-	-	-	-	-
Eragrostis benthamii	0	-	-	-	-	+	-	-	-	-	-
Eragrostis leptostachya	2.44	-	-	-	-	-	-	-	-	-	-
Eragrostis parviflora	0										
Eragrostis trachycarpa	0	-	-	-	-	+	-	-	-	-	-
Festuca asperula	0.03	-	-	+	-	-	-	-	-	-	-
Glyceria australis	0	-	-	-	-	+	-	-	-	-	-
Hemarthria uncinata var. *uncinata*	0.10	-	-	-	-	-	-	-	-	-	-
Hierochloe rariflora	12.46	-	-	-	-	-	-	-	-	-	-
Imperata cylindrica var. *major*	6.54	-	-	-	-	-	-	-	-	-	-
Isachne globosa	0.17	-	-	+	-	-	-	-	-	-	-
Microlaena stipoides var. *stipoides*	23.54	-	-	-	-	-	-	-	-	-	-
Notodanthonia caespitosa	0.07	-	-	-	-	-	-	-	-	-	-
Notodanthonia eriantha	0.03	-	-	-	-	+	-	-	-	-	-

Appendix 1 cont.	**Freq. (%)**	**1**	**2**	**3**	**4**	**5**	**5X**	**6**	**7**	**8**	**9**
Poaceae cont.											
Notodanthonia laevis	0.24	-	-	-	-	-	-	-	-	-	-
Notodanthonia linkii var. *fulva*	0	-	-	-	-	-	-	-	-	-	-
Notodanthonia monticola	0.10	-	-	-	-	-	-	-	-	-	-
Notodanthonia penicillata	0.24	-	-	-	-	-	-	-	-	-	-
Notodanthonia pilosa var. *pilosa*	3.82	-	-	-	-	-	-	-	-	-	-
Notodanthonia racemosa var. *racemosa*	2.68	-	-	-	-	-	-	-	-	-	-
Notodanthonia setacea	0.10	-	-	-	-	+	-	-	-	-	-
Notodanthonia tenuior	0.58	-	-	-	-	-	-	-	-	-	-
Oplismenus aemulus	1.00	-	-	-	-	-	-	-	-	-	-
Oplismenus imbecillis	10.56	-	-	-	-	-	-	-	-	-	-
Panicum bisulcatum	0	-	-	-	-	+	-	-	-	-	-
Panicum simile	0.83	-	-	-	-	-	-	-	-	-	-
Paspalum distichum	0.03	-	-	-	-	-	-	-	-	-	-
Paspalum orbiculare	0.03	-	-	-	-	+	-	-	-	-	-
Pentapogon quadrifidus	0.03	-	-	-	-	+	-	-	-	-	-
Phragmites australis	0.89	-	-	-	-	-	-	-	-	-	-
Plinthanthesis paradoxa	0.28	-	-	-	-	-	-	-	-	-	-
Poa affinis	0.38	-	-	-	-	+	-	-	S	-	-
Poa cheelii	0.14	-	-	-	-	-	-	-	S	-	-
Poa clivicola	0.48	-	-	-	-	-	-	-	-	-	-
Poa costiniana	0.10	-	-	-	-	-	-	-	-	-	-
Poa ensiformis	4.71	-	-	-	-	-	-	-	-	-	-
Poa helmsii	0.07	-	-	-	-	-	-	-	-	-	-
Poa labillardieri	15.62	-	-	-	-	-	-	-	-	-	-
Poa meionectes	44.67	-	-	-	-	-	-	-	-	-	-
Poa poiformis	0.31	-	-	-	-	-	-	-	-	-	-
Poa queenslandica	0	-	-	-	-	+	-	-	S	-	-
Poa sieberiana var. *cyanophylla*	0.07	-	-	-	-	-	-	-	-	-	-
Poa sieberiana var. *hirtella*	0	-	-	-	-	+	-	-	-	-	-
Poa sieberiana var. *sieberiana*	1.24	-	-	-	-	-	-	-	-	-	-
Poa tenera	0.38	-	-	-	-	-	-	-	-	-	-
Sorghum leiocladum	0.24	-	-	-	-	-	-	-	-	-	-
Spinifex sericeus	1.65	-	-	-	-	-	-	-	-	-	-
Sporobolus creber	0.55	-	-	-	-	-	-	-	-	-	-
Sporobolus elongatus	0	-	-	-	-	+	-	-	S	-	-
Sporobolus virginicus	1.82	-	-	-	-	-	-	-	-	-	-
Tetrarrhena acuminata	0	-	-	+	-	-	-	-	N	-	-
Tetrarrhena juncea	10.81	-	-	-	-	-	-	-	-	-	-
Tetrarrhena turfosa	0.21	-	-	-	-	+	-	-	-	-	-
Themeda australis	10.70	-	-	-	-	-	-	-	-	-	-
Thonandia longifolia	7.57	-	-	-	-	-	-	-	-	-	-
Thonandia semiannularis	0	-	-	-	-	-	-	-	-	-	-
Tripogon loliiformis	0	-	-	-	-	+	-	-	-	-	-
Trisetum spicatum	0.03	-	-	-	-	+	-	-	-	-	-
Zoysia macrantha	1.58	-	-	-	-	-	-	-	-	-	-
Posidoniaceae											
Posidonia australis	0	-	-	-	-	-	-	-	-	-	-
Potamogetonaceae											
Potamogeton crispus	0	-	-	-	-	+	-	-	-	-	-
Potamogeton ochreatus	0	-	-	-	-	-	-	-	-	-	-
Potamogeton tricarinatus	0.03	-	-	-	-	-	-	-	-	-	-
Ruppia polycarpa	0	-	-	-	-	-	-	-	-	-	-

Appendix 1 cont.	**Freq. (%)**	**1**	**2**	**3**	**4**	**5**	**5X**	**6**	**7**	**8**	**9**
Restionaceae											
Baloskion australe	0.41	-	-	-	-	-	-	-	-	-	-
Baloskion tetraphyllum subsp. *tetraphyllum*	0	-	-	-	-	+	-	-	N	-	-
Calorophus elongatus	0	-	-	-	-	+	-	-	N	-	-
Empodisma minus	1.55	-	-	-	-	-	-	-	-	-	-
Eurychorda complanata	0.21	-	-	-	-	-	-	-	-	-	-
Hypolaena fastigiata	0.69	-	-	-	-	-	-	-	-	-	-
Leptocarpus tenax	0.69	-	-	-	-	-	-	-	-	-	-
Lepyrodia anarthria	0.41	-	-	-	-	-	-	-	-	-	-
Lepyrodia muelleri	0	-	-	-	-	+	-	-	-	-	-
Lepyrodia scariosa	0.45	-	-	-	-	-	-	-	S	-	-
Lepyrodia verruculosa	0	-	-	-	-	-	-	-	S	-	-
Ripogonaceae											
Ripogonum album	0.34	-	-	-	-	-	-	-	-	-	-
Smilacaceae											
Smilax australis	17.52	-	-	-	-	-	-	-	-	-	-
Smilax glyciphylla	0	-	-	-	-	+	-	-	S	-	-
Sparganiaceae											
Sparganium subglobosum	0	-	-	+	-	-	-	-	-	-	-
Typhaceae											
Typha domingensis	0	-	-	-	-	+	-	-	-	-	-
Typha orientalis	0	-	-	-	-	-	-	-	-	-	-
Uvulariaceae											
Schelhammera undulata	5.99	-	-	-	-	-	-	-	-	-	-
Xanthorrhoeaceae											
Xanthorrhoea australis	2.51	-	-	-	-	-	-	-	-	-	-
Xanthorrhoea concava	3.96	-	-	-	-	-	-	-	S	-	-
Xanthorrhoea minor subsp. *lutea*	0.03	-	-	-	-	+	-	-	N	-	-
Xanthorrhoea resinifera	0.86	-	-	-	-	-	-	-	-	-	-
Xyridaceae											
Xyris gracilis subsp. *gracilis*	0.45	-	-	-	-	-	-	-	LN	-	-
Xyris operculata	0.69	-	-	-	-	-	-	-	-	-	-
Zannichelliaceae											
Lepilaena bilocularis	0	-	-	-	-	-	-	-	-	-	-
Zosteraceae											
Zostera capricorni	0	-	-	-	-	-	-	-	-	-	-
Zostera muelleri	0	-	-	-	-	-	-	-	-	-	-
MAGNOLIOPSIDA (MAGNOLIIDAE)											
Acanthaceae											
Brunoniella pumilio	0.21	-	-	-	-	-	-	-	-	-	-
Pseuderanthemum variabile	0.96	-	-	-	-	-	-	-	S	-	-
Aizoaceae											
Carpobrotus glaucescens	1.65	-	-	-	-	-	-	-	-	-	-
Disphyma crassifolium subsp. *clavellatum*	0.38	-	-	-	-	+	-	-	-	-	-
Tetragonia tetragonoides	0.41	-	-	-	-	-	-	-	-	-	-
Amaranthaceae											
Alternanthera denticulata	0.10	-	-	-	-	+	-	-	-	-	-
Deeringia amaranthoides	0.21	-	-	-	-	-	-	-	S	-	-

Appendix 1 cont.	**Freq. (%)**	**1**	**2**	**3**	**4**	**5**	**5X**	**6**	**7**	**8**	**9**
Apiaceae											
Actinotus gibbonsii	0	-	-	+	-	-	-	-	S	+	-
Actinotus helianthi	0	-	-	-	-	+	-	-	S	-	-
Apium prostratum subsp. *prostratum* var. *filiforme*	0.03	-	-	-	-	+	-	-	-	-	-
Apium prostratum subsp. *prostratum* var. *prostratum*	0.79	-	-	-	-	-	-	-	-	-	-
Centella asiatica	0.58	-	-	-	-	-	-	-	-	-	-
Centella cordifolia	0.10	-	-	-	-	+	-	-	-	-	-
Daucus glochidiatus	0.93	-	-	-	-	-	-	-	-	-	-
Eryngium rostratum	0	-	-	-	-	+	+	+	-	-	-
Hydrocotyle acutiloba	10.87	-	-	-	-	-	-	-	-	-	-
Hydrocotyle algida	0.03	-	-	-	-	+	-	-	-	-	-
Hydrocotyle geraniifolia	0.96	-	-	-	-	-	-	-	-	-	-
Hydrocotyle laxiflora	15.28	-	-	-	-	-	-	-	-	-	-
Hydrocotyle peduncularis	1.07	-	-	-	-	-	-	-	-	-	-
Hydrocotyle tripartita	1.14	-	-	-	-	-	-	-	-	-	-
Lilaeopsis polyantha	0.17	-	-	-	-	-	-	-	-	-	-
Oreomyrrhis ciliata	0.14	-	-	-	-	-	-	-	-	-	-
Oreomyrrhis eriopoda	0.38	-	-	-	-	-	-	-	-	-	-
Platysace ericoides	0.03	-	-	-	-	-	-	-	-	-	-
Platysace heterophylla	0.03	-	-	-	-	+	-	-	N	-	-
Platysace lanceolata	29.94	-	-	-	-	-	-	-	-	-	-
Trachymene anisocarpa	0	-	-	-	-	+	-	-	-	-	-
Trachymene humilis subsp. *humilis*	0.10	-	-	-	-	+	-	-	-	-	-
Xanthosia atkinsoniana	0.38	-	-	-	-	-	-	-	S	-	-
Xanthosia dissecta	0.31	-	-	-	-	-	-	-	-	-	-
Xanthosia pilosa	4.40	-	-	-	-	-	-	-	-	-	-
Xanthosia pusilla	0.14	-	-	-	-	-	-	-	N	-	-
Xanthosia ternifolia	0	-	-	-	-	+	-	-	-	-	-
Xanthosia tridentata	1.27	-	-	-	-	-	-	-	-	-	-
Apocynaceae											
Alyxia buxifolia	0.17	-	-	-	-	-	-	-	-	-	-
Parsonsia brownii	2.00	-	-	-	-	-	-	-	-	-	-
Parsonsia straminea	0.55	-	-	-	-	-	-	-	S	-	-
Araliaceae											
Astrotricha latifolia	0.07	-	-	-	-	+	-	-	-	-	-
Astrotricha ledifolia	0	-	-	-	-	+	-	-	-	-	-
Astrotricha sp. 'Nadgee'	0	+	-	+	-	-	-	-	-	-	-
Astrotricha sp. 'Wallagaraugh'	0	-	-	+	-	-	-	-	N	-	-
Polyscias murrayi	0.31	-	-	-	-	-	-	-	-	-	-
Polyscias sambucifolia subsp. A	7.09	-	-	-	-	-	-	-	-	-	-
Polyscias sambucifolia subsp. C	7.09	-	-	-	-	-	-	-	-	-	-
Asclepiadaceae											
Marsdenia flavescens	0.52	-	-	-	-	-	-	-	-	-	-
Marsdenia rostrata	9.15	-	-	-	-	-	-	-	-	-	-
Marsdenia suaveolens	1.07	-	-	-	-	-	-	-	S	-	-
Tylophora barbata	22.75	-	-	-	-	-	-	-	-	-	-
Asteraceae											
Actites megalocarpa	0.76	-	-	-	-	-	-	-	-	-	-
Ammobium alatum	0	-	-	-	-	+	+	-	-	-	-
Apalochlamys spectabilis	0.07	-	-	-	-	+	-	-	N	-	-
Argentipallium obtusifolium	0.21	-	-	-	-	-	-	-	N	-	-

Appendix 1 cont.	**Freq. (%)**	**1**	**2**	**3**	**4**	**5**	**5X**	**6**	**7**	**8**	**9**
Asteraceae cont.											
Arrhenechthites mixta	1.86	-	-	-	-	-	-	-	-	-	-
Bedfordia arborescens	11.22	-	-	-	-	-	-	-	-	-	-
Brachycome aculeata	0.28	-	-	-	-	-	-	-	-	-	-
Brachycome angustifolia var. *angustifolia*	0	-	-	-	-	+	-	-	-	-	-
Brachycome angustifolia var. *heterophylla*	0.86	-	-	-	-	-	-	-	-	-	-
Brachycome cardiocarpa	0.17	-	-	-	-	-	-	-	-	-	-
Brachycome ciliaris var. *ciliaris*	0.10	-	-	-	-	+	-	-	-	-	-
Brachycome decipiens	0.14	-	-	-	-	-	-	-	-	-	-
Brachycome graminea	0	-	-	-	-	+	-	-	-	-	-
Brachycome obovata	0	-	-	-	-	+	-	-	-	-	-
Brachycome radicans	0	-	-	-	-	+	-	-	-	-	-
Brachycome rigidula	0	-	-	-	-	+	-	-	-	-	-
Brachycome scapigera	0.17	-	-	-	-	+	-	-	-	-	-
Brachycome spathulata	0.07	-	-	-	-	+	-	-	-	-	-
Bracteantha bracteata species complex	4.78	-	-	-	-	-	-	-	-	-	-
Bracteantha subundulata	0.07	-	-	-	-	+	-	-	-	-	+
Bracteantha viscosa	0.03	-	-	-	-	+	-	-	-	-	-
Calocephalus lacteus	0	-	-	-	-	+	-	-	N	-	-
Calomeria amaranthoides	0.31	-	-	-	-	-	-	-	-	-	-
Calotis glandulosa	0	-	+	-	-	-	-	-	S	-	-
Calotis lappulacea	0.10	-	-	-	-	+	-	-	-	-	-
Cassinia aculeata	11.84	-	-	-	-	-	-	-	-	-	-
Cassinia aureonitens	0	-	-	-	-	+	-	-	S	+	-
Cassinia cunninghamii	0	-	-	-	-	+	-	-	S	+	-
Cassinia longifolia	13.08	-	-	-	-	-	-	-	-	-	-
Cassinia trinerva	7.78	-	-	-	-	-	-	-	-	-	-
Cassinia uncata	0	-	-	-	-	+	-	-	-	-	-
Celmisia sp. (*pulchella* ms)	0.03	-	-	-	-	+	-	-	-	-	-
Centipeda minima var. *minima*	0.17	-	-	-	-	-	-	-	-	-	-
Chrysocephalum apiculatum	0.31	-	-	-	-	-	-	-	-	-	-
Chrysocephalum baxteri	0.31	-	-	-	-	-	-	-	N	-	-
Chrysocephalum semipapposum	0.65	-	-	-	-	-	-	-	-	-	-
Cotula alpina	0.10	-	-	-	-	+	-	-	-	-	-
Cotula australis	0.38	-	-	-	-	-	-	-	-	-	-
Craspedia canens	0.43	-	-	-	-	-	-	-	-	-	-
Craspedia paludicola	0	-	-	-	-	+	-	-	-	-	-
Craspedia variabilis	0.14	-	-	-	-	-	-	-	-	-	-
Cymbonotus lawsonianus	0	-	-	-	-	+	-	-	-	-	-
Cymbonotus preissianus	1.79	-	-	-	-	-	-	-	-	-	-
Euchiton sphaericus	0.93	-	-	-	-	-	-	-	-	-	-
Gnaphalium gymnocephalum	10.84	-	-	-	-	-	-	-	-	-	-
Gnaphalium involucratum	0.69	-	-	-	-	-	-	-	-	-	-
Gnaphalium spicatum	0.03	-	-	-	-	+	-	-	-	-	-
Helichrysum collinum	0.03	-	-	-	-	+	-	-	S	+	-
Helichrysum elatum	3.54	-	-	-	-	-	-	-	-	-	-
Helichrysum leucopsideum	0.62	-	-	-	-	-	-	-	-	-	-
Helichrysum rutidolepis	0.89	-	-	-	-	-	-	-	-	-	-
Helichrysum scorpioides	9.08	-	-	-	-	-	-	-	-	-	-
Lagenifera gracilis	0.24	-	-	-	-	-	-	-	-	-	-
Lagenifera stipitata	24.60	-	-	-	-	-	-	-	-	-	-
Leptinella filicula	1.34	-	-	-	-	-	-	-	-	-	-
Leptinella longipes	0.07	-	-	-	-	+	-	-	-	-	-
Leptorhynchos nitidulus	0.10	-	-	-	-	+	-	-	-	-	-

Appendix 1 cont.	**Freq. (%)**	**1**	**2**	**3**	**4**	**5**	**5X**	**6**	**7**	**8**	**9**
Asteraceae cont.											
Leptorhynchos squamatus subsp. A	0.10	-	-	-	-	+	-	-	-	-	-
Leucochrysum albicans subsp. *albicans*	0	-	-	-	-	+	-	-	-	-	-
Microseris lanceolata	0	-	-	-	-	-	-	+	-	-	-
Olearia alpicola	0.07	-	-	-	-	+	-	-	-	-	-
Olearia argophylla	7.78	-	-	-	-	-	-	-	-	-	-
Olearia axillaris	0.14	-	-	-	-	+	-	-	-	-	-
Olearia erubescens	5.75	-	-	-	-	-	-	-	-	-	-
Olearia glandulosa	0.17	-	-	-	-	-	-	-	-	-	-
Olearia iodochroa	0.41	-	-	-	-	-	-	-	-	-	-
Olearia megalophylla	1.14	-	-	-	-	-	-	-	-	-	-
Olearia myrsinoides	0.52	-	-	-	-	-	-	-	-	-	-
Olearia phlogopappa	0.79	-	-	-	-	-	-	-	-	-	-
Olearia ramulosa subsp. D	0.62	-	-	-	-	-	-	-	-	-	-
Olearia rugosa	0	-	-	-	-	+	-	-	N	-	-
Olearia stellulata	3.48	-	-	-	-	-	-	-	-	-	-
Olearia tomentosa	0.83	-	-	-	-	-	-	-	S	-	-
Ozothamnus argophyllus	5.30	-	-	-	-	-	-	-	-	-	-
Ozothamnus conditus	0.17	-	-	-	-	+	-	-	-	-	-
Ozothamnus cuneifolius	4.78	-	-	-	-	-	-	-	-	-	-
Ozothamnus diosmifolius	9.19	-	-	-	-	-	-	-	S	-	-
Ozothamnus ferrugineus	3.27	-	-	-	-	-	-	-	-	-	-
Ozothamnus obcordatus subsp. *major*	1.24	-	-	-	-	-	-	-	-	-	-
Ozothamnus rosmarinifolius	0.31	-	-	-	-	-	-	-	LN	-	-
Ozothamnus thyrsoideus	0.41	-	-	-	-	-	-	-	-	-	-
Ozothamnus turbinatus	0	-	-	-	-	+	-	-	N	-	-
Picris angustifolia subsp. *angustifolia*	0.62	-	-	-	-	-	-	-	-	-	-
Podolepis hieracioides	0.14	-	-	-	-	-	-	-	-	-	-
Podolepis jaceoides	0.03	-	-	-	-	+	-	-	-	-	-
Pseudognaphalium luteoalbum	0.55	-	-	-	-	-	-	-	-	-	-
Rutidosis leiolepis	0	-	+	-	-	-	-	-	-	-	-
Senecio bipinnatisectus	0.21	-	-	-	-	-	-	-	S	-	-
Senecio biserratus	0.10	-	-	-	-	+	-	-	-	-	-
Senecio diaschides	0.03	-	-	-	-	-	-	-	-	-	-
Senecio glomeratus	1.27	-	-	-	-	-	-	-	S	-	-
Senecio hispidulus var. *dissectus*	0.17	-	-	-	-	-	-	-	-	-	-
Senecio hispidulus var. *hispidulus*	1.31	-	-	-	-	-	-	-	-	-	-
Senecio lautus subsp. *dissectifolius*	0	-	-	-	-	+	-	-	-	-	-
Senecio lautus subsp. *maritimus*	0.72	-	-	-	-	-	-	-	-	-	-
Senecio linearifolius	18.58	-	-	-	-	-	-	-	-	-	-
Senecio minimus	2.62	-	-	-	-	-	-	-	-	-	-
Senecio quadridentatus	0.83	-	-	-	-	-	-	-	-	-	-
Senecio spathulatus	0	-	+	-	-	-	-	-	-	-	-
Senecio sp. E	13.39	-	-	-	-	-	-	-	-	-	-
Senecio squarrosus	0	-	+	-	-	-	-	-	N	-	-
Senecio tenuiflorus	0	-	-	-	-	-	-	-	-	-	-
Senecio velleioides	3.23	-	-	-	-	-	-	-	-	-	-
Sigesbeckia orientalis subsp. *orientalis*	5.64	-	-	-	-	-	-	-	-	-	-
Solenogyne gunnii	0.07	-	-	-	-	+	-	-	-	-	-
Sonchus hygrophilus	0	-	-	-	-	+	-	-	S	-	-
Triptilodiscus pygmaeus	0	-	-	-	-	+	-	-	-	-	-
Vernonia cinerea var. *cinerea*	3.92	-	-	-	-	-	-	-	S	-	-
Vittadinia dissecta	0.03	-	-	-	-	+	-	-	-	-	-

Appendix 1 cont.	Freq. (%)	1	2	3	4	5	5X	6	7	8	9
Asteraceae cont.											
Vittadinia cuneata var. *cuneata* forma *cuneata*	0	-	-	-	-	+	-	-	-	-	-
Vittadinia cuneata var. *cuneata* forma *minor*	0.24	-	-	-	-	-	-	-	-	-	-
Vittadinia muelleri	0.03	-	-	-	-	+	-	-	-	-	-
Vittadinia tenuissima	0.07	-	-	-	-	+	-	-	-	-	-
Avicenniaceae											
Avicennia marina var. *australasica*	1.03	-	-	-	-	-	-	-	-	-	-
Baueraceae											
Bauera rubioides	0.17	-	-	-	-	-	-	-	-	-	-
Bignoniaceae											
Pandorea pandorana	13.04	-	-	-	-	-	-	-	-	-	-
Boraginaceae											
Austrocynoglossum latifolium	1.27	-	-	-	-	-	-	-	-	-	-
Cynoglossum australe	1.96	-	-	-	-	-	-	-	-	-	-
Cynoglossum suaveolens	0.79	-	-	-	-	-	-	-	-	-	-
Ehretia acuminata var. *acuminata*	0.10	-	-	-	-	-	-	-	S	-	-
Myosotis australis	0.24	-	-	-	-	-	-	-	-	-	-
Brassicaceae											
Cardamine gunnii	0.07	-	-	-	-	+	-	-	-	-	-
Cardamine lilacina	0.10	-	-	-	-	+	-	-	-	-	-
Cardamine microthrix	0	-	-	-	-	+	-	-	-	-	-
Cardamine papillata	0	-	-	-	-	+	-	-	-	-	-
Cardamine paucijuga	0.21	-	-	-	-	-	-	-	-	-	-
Cardamine sp. A1	0	-	-	-	-	+	-	-	-	-	-
Lepidium hyssopifolium	0.03	-	+	-	-	-	-	-	-	-	-
Lepidium pseudotasmanicum	0	-	-	+	-	-	-	-	-	-	-
Rorippa dictyosperma	0	-	-	-	-	+	-	-	-	-	-
Rorippa gigantea	0.24	-	-	-	-	-	-	-	-	-	-
Callitrichaceae											
Callitriche muelleri	0.07	-	-	-	-	+	-	-	-	-	-
Campanulaceae											
Wahlenbergia communis	0.72	-	-	-	-	-	-	-	-	-	-
Wahlenbergia gloriosa	0.14	-	-	-	-	+	-	-	-	-	-
Wahlenbergia gracilis	8.60	-	-	-	-	-	-	-	-	-	-
Wahlenbergia littoricola	0.38	-	-	-	-	-	-	-	-	-	-
Wahlenbergia luteola	0	-	-	-	-	+	-	-	-	-	-
Wahlenbergia multicaulis	0	-	-	-	-	+	-	-	-	-	-
Wahlenbergia planiflora subsp. *planiflora*	0.07	-	-	-	-	+	-	-	-	-	-
Wahlenbergia stricta subsp. *stricta*	4.40	-	-	-	-	-	-	-	-	-	-
Caryophyllaceae											
Scleranthus biflorus	1.17	-	-	-	-	-	-	-	-	-	-
Scleranthus diander	0.03	-	-	-	-	+	-	-	-	-	-
Spergularia sp. B	0	-	-	-	-	+	-	-	-	-	-
Stellaria angustifolia	0.14	-	-	-	-	-	-	-	-	-	-
Stellaria flaccida	14.97	-	-	-	-	-	-	-	-	-	-
Stellaria multiflora	0	-	-	+	-	-	-	-	-	-	-
Stellaria pungens	5.13	-	-	-	-	-	-	-	-	-	-

Appendix 1 cont.	**Freq. (%)**	**1**	**2**	**3**	**4**	**5**	**5X**	**6**	**7**	**8**	**9**
Casuarinaceae											
Allocasuarina diminuta subsp. *annectens*	0	-	-	-	-	+	-	-	S	+	-
Allocasuarina distyla	0.03	-	-	-	-	+	-	-	S	-	-
Allocasuarina littoralis	20.82	-	-	-	-	-	-	-	-	-	-
Allocasuarina nana	2.06	-	-	-	-	-	-	-	-	-	-
Allocasuarina paludosa	1.65	-	-	-	-	-	-	-	-	-	-
Allocasuarina verticillata	0.28	-	-	-	-	-	-	-	-	-	-
Casuarina cunninghamiana subsp. *cunninghamiana*	0.48	-	-	-	-	-	-	-	S	-	-
Casuarina glauca	0.14	-	-	-	-	-	-	-	S	-	-
Celasteraceae											
Celastrus australis	0.76	-	-	-	-	-	-	-	-	-	-
Celastrus subspicata	0	-	-	-	-	+	-	-	S	+	-
Chenopodiaceae											
Atriplex australasica	0.48	-	-	-	-	-	-	-	-	-	-
Atriplex cinerea	0	-	-	-	-	+	-	-	-	-	-
Atriplex semibaccata	0	-	-	-	-	+	-	-	-	-	-
Chenopodium carinatum	0.07	-	-	-	-	+	-	-	-	-	-
Chenopodium glaucum	0.07	-	-	-	-	-	-	-	-	-	-
Chenopodium pumilio	0.03	-	-	-	-	+	-	-	-	-	-
Einadia hastata	0.93	-	-	-	-	-	-	-	-	-	-
Einadia nutans subsp. *nutans*	1.24	-	-	-	-	-	-	-	-	-	-
Einadia trigonos subsp. *trigonos*	0.21	-	-	-	-	-	-	-	-	-	-
Enchylaena tomentosa	0	-	-	-	-	+	-	-	-	-	-
Rhagodia candolleana subsp. *candolleana*	1.58	-	-	-	-	-	-	-	-	-	+
Sarcocornia quinqueflora subsp. *quinqueflora*	3.96	-	-	-	-	-	-	-	-	-	-
Sclerostegia arbuscula	0.86	-	-	-	-	-	-	-	-	-	-
Suaeda australis	0.86	-	-	-	-	-	-	-	-	-	-
Chloanthaceae											
Chloanthes parviflora	0.14	-	-	-	-	-	-	-	-	-	-
Clusiaceae											
Hypericum gramineum	17.72	-	-	-	-	-	-	-	-	-	-
Hypericum japonicum	4.16	-	-	-	-	-	-	-	-	-	-
Convolvulaceae											
Calystegia marginata	0.45	-	-	-	-	-	-	-	-	-	-
Calystegia sepium	0	-	-	-	-	+	-	-	-	-	-
Calystegia soldanella	0.52	-	-	-	-	-	-	-	-	-	-
Convolvulus erubescens	0.34	-	-	-	-	-	-	-	-	-	-
Dichondra repens	18.62	-	-	-	-	-	-	-	-	-	-
Polymeria calycina	0	-	-	-	-	+	-	-	S	-	-
Wilsonia backhousei	0.38	-	-	+	-	-	-	-	-	+	-
Crassulaceae											
Crassula helmsii	0	-	-	-	-	+	-	-	-	-	-
Crassula peduncularis	0	-	-	-	-	+	-	-	-	-	-
Crassula sieberiana subsp. *sieberiana*	1.93	-	-	-	-	-	-	-	-	-	-
Cucurbitaceae											
Sicyos australis	0.45	-	-	-	-	+	-	-	-	-	-
Cunoniaceae											
Aphanopetalum resinosum	1.82	-	-	-	-	-	-	-	-	-	-
Schizomeria ovata	0.03	-	-	-	-	+	-	-	S	-	-

Appendix 1 cont.	Freq. (%)	1	2	3	4	5	5X	6	7	8	9
Dilleniaceae											
Hibbertia acicularis	0.41	-	-	-	-	-	-	-	-	-	-
Hibbertia aspera	12.08	-	-	-	-	-	-	-	-	-	-
Hibbertia astrotricha	0	-	-	-	-	+	-	-	-	-	-
Hibbertia circumdans	0.31	-	-	-	-	-	-	-	S	-	-
Hibbertia dentata	9.19	-	-	-	-	-	-	-	-	-	-
Hibbertia diffusa	0.96	-	-	-	-	-	-	-	-	-	-
Hibbertia empetrifolia	5.13	-	-	-	-	-	-	-	-	-	-
Hibbertia fasciculata var. *fasciculata*	0.10	-	-	-	-	+	-	-	S	-	-
Hibbertia hermanniifolia	0.10	-	-	+	-	-	-	-	-	-	-
Hibbertia linearis	1.34	-	-	-	-	-	-	-	S	-	-
Hibbertia obtusifolia	8.05	-	-	-	-	-	-	-	-	-	-
Hibbertia pedunculata	0.62	-	-	-	-	-	-	-	-	-	-
Hibbertia prostrata	0	-	-	-	-	+	-	-	-	-	-
Hibbertia riparia	0.17	-	-	-	-	-	-	-	-	-	-
Hibbertia saligna	0.03	-	-	-	-	+	-	-	S	+	-
Hibbertia serpyllifolia	0.24	-	-	-	-	+	-	-	-	-	-
Hibbertia virgata subsp. *virgata*	0.14	-	-	-	-	-	-	-	-	-	-
Hibbertia sp. aff. *hermanniifolia*	0.07	+	-	-	-	+	-	-	-	-	-
Droseraceae											
Drosera auriculata	0.69	-	-	-	-	-	-	-	-	-	-
Drosera binata	0.24	-	-	-	-	-	-	-	-	-	-
Drosera glanduligera	0.03	-	-	-	-	+	-	-	-	-	-
Drosera peltata	0.79	-	-	-	-	-	-	-	-	-	-
Drosera pygmaea	0.10	-	-	-	-	+	-	-	-	-	-
Drosera spathulata	0.28	-	-	-	-	-	-	-	-	-	-
Elaeocarpaceae											
Elaeocarpus holopetalus	1.20	-	-	-	-	-	-	-	-	-	-
Elaeocarpus reticulatus	8.29	-	-	-	-	-	-	-	-	-	-
Elatinaceae											
Elatine gratioloides	0	-	-	-	-	+	-	-	-	-	-
Epacridaceae											
Acrotriche leucocarpa	0.28	-	-	+	-	-	-	-	-	-	-
Acrotriche serrulata	5.85	-	-	-	-	-	-	-	-	-	-
Astroloma humifusum	4.58	-	-	-	-	-	-	-	-	-	-
Astroloma pinifolium	0.03	-	-	-	-	+	-	-	-	-	-
Brachyloma daphnoides subsp. *daphnoides*	3.17	-	-	-	-	-	-	-	-	-	-
Epacris breviflora	0.14	-	-	-	-	-	-	-	-	-	-
Epacris impressa	16.24	-	-	-	-	-	-	-	-	-	-
Epacris lanuginosa	0	-	-	-	-	+	-	-	N	-	-
Epacris microphylla var. *microphylla*	0.93	-	-	-	-	-	-	-	-	-	-
Epacris microphylla var. *rhombifolia*	0.14	-	-	+	-	-	-	-	S	-	-
Epacris obtusifolia	0.48	-	-	-	-	-	-	-	-	-	-
Epacris paludosa	0.76	-	-	-	-	-	-	-	-	-	-
Epacris petrophila	0.03	-	-	-	-	+	-	-	-	-	-
Epacris robusta	0.14	-	-	-	-	+	-	-	S	-	-
Leucopogon attenuatus	0.28	-	-	-	-	+	-	-	-	-	-
Leucopogon collinus	0	-	-	-	-	+	-	-	LN	-	-
Leucopogon ericoides	0.69	-	-	-	-	-	-	-	-	-	-
Leucopogon esquamatus	0.28	-	-	-	-	-	-	-	-	-	-
Leucopogon fletcheri subsp. *brachysepalus*	0	-	-	-	-	+	-	-	-	-	-

Appendix 1 cont.	**Freq. (%)**	**1**	**2**	**3**	**4**	**5**	**5X**	**6**	**7**	**8**	**9**
Epacridaceae cont.											
Leucopogon fraseri	0.28	-	-	-	-	-	-	-	-	-	-
Leucopogon gelidus	0.38	-	-	-	-	-	-	-	-	-	-
Leucopogon hookeri	0.07	-	-	-	-	+	-	-	-	-	-
Leucopogon juniperinus	3.13	-	-	-	-	-	-	-	-	-	-
Leucopogon lanceolatus var. *lanceolatus*	38.82	-	-	-	-	-	-	-	-	-	-
Leucopogon microphyllus var. *pilibundus*	0.41	-	-	-	-	-	-	-	-	-	-
Leucopogon parviflorus	1.10	-	-	-	-	-	-	-	-	-	-
Leucopogon pilifer	0	-	-	-	-	+	-	-	-	-	-
Leucopogon setiger	0.31	-	-	-	-	+	-	-	S	+	-
Leucopogon virgatus	0.45	-	-	-	-	-	-	-	-	-	-
Lissanthe strigosa subsp. *subulata*	1.31	-	-	-	-	-	-	-	-	-	-
Melichrus urceolatus	0.28	-	-	-	-	-	-	-	-	-	-
Monotoca albens	0.24	-	-	-	-	+	-	-	-	-	-
Monotoca elliptica	1.55	-	-	-	-	-	-	-	-	-	-
Monotoca rotundifolia	0	-	+	-	-	-	-	-	-	-	-
Monotoca scoparia	11.01	-	-	-	-	-	-	-	-	-	-
Sprengelia incarnata	0.58	-	-	-	-	-	-	-	-	-	-
Styphelia adscendens	0.03	-	-	-	-	+	-	-	-	-	-
Styphelia psiloclada	0.28	-	-	+	-	-	-	-	-	-	-
Trochocarpa laurina	0	-	-	-	-	+	+	-	S	+	-
Ericaceae											
Gaultheria appressa	0.34	-	-	-	-	+	-	-	-	-	-
Eucryphiaceae											
Eucryphia moorei	0.41	-	-	+	-	-	-	-	-	-	-
Euphorbiaceae											
Adriana glabrata var. *subglabra*	0	-	-	-	-	+	-	-	-	-	-
Amperea xiphoclada var. *xiphoclada*	5.92	-	-	-	-	-	-	-	-	-	-
Bertya rosmarinifolia	0.03	-	-	-	-	+	-	-	-	-	-
Beyeria lasiocarpa	4.40	-	-	-	-	-	-	-	-	-	-
Beyeria viscosa	0	-	-	-	-	+	-	-	-	-	-
Breynia oblongifolia	3.99	-	-	-	-	-	-	-	S	-	-
Claoxylon australe	0.69	-	-	-	-	-	-	-	S	-	-
Micranthium hexandrum	0	-	-	-	-	+	-	-	-	-	-
Omalanthus populifolius	0.24	-	-	-	-	-	-	-	S	-	-
Omalanthus stillingifolius	0	-	-	-	-	+	-	-	S	-	-
Phyllanthus gasstroemii	0.79	-	-	-	-	-	-	-	-	-	-
Phyllanthus gunnii	1.03	-	-	-	-	-	-	-	-	-	-
Phyllanthus hirtellus	1.89	-	-	-	-	-	-	-	-	-	-
Phyllanthus similis	0.24	-	-	-	-	-	-	-	-	-	-
Poranthera corymbosa	0.41	-	-	-	-	-	-	-	-	-	-
Poranthera ericifolia	0.07	-	-	-	-	+	-	-	S	-	-
Poranthera microphylla	16.55	-	-	-	-	-	-	-	-	-	-
Pseudanthus divaricatissimus	0.21	-	-	+	-	-	-	-	-	-	-
Pseudanthus ovalifolius	0	-	+	-	-	+	-	-	N	+	-
Ricinocarpos pinifolius	0.62	-	-	-	-	-	-	-	-	-	-
Eupomatiaceae											
Eupomatia laurina	1.55	-	-	-	-	-	-	-	-	-	-
Fabaceae (Caesalpinioideae)											
Senna aciphylla	0	-	-	-	-	+	-	-	-	-	-
Senna odorata	0.03	-	-	-	-	+	-	-	S	-	-

Appendix 1 cont.	**Freq. (%)**	**1**	**2**	**3**	**4**	**5**	**5X**	**6**	**7**	**8**	**9**
Fabaceae (Faboideae)											
Almaleea paludosa	0.03	-	-	-	-	+	-	-	-	-	-
Almaleea subumbellata	0.03	-	-	-	-	+	-	-	-	-	-
Aotus ericoides	2.72	-	-	-	-	-	-	-	-	-	-
Bossiaea bracteosa	0.03	-	-	-	-	+	-	-	-	-	-
Bossiaea buxifolia	2.10	-	-	-	-	-	-	-	-	-	-
Bossiaea cinerea	0.03	-	-	-	-	-	-	-	N	-	-
Bossiaea ensata	0.76	-	-	-	-	-	-	-	-	-	-
Bossiaea foliosa	1.58	-	-	-	-	-	-	-	-	-	-
Bossiaea heterophylla	0.69	-	-	-	-	-	-	-	-	-	-
Bossiaea obcordata	4.44	-	-	-	-	-	-	-	-	-	-
Bossiaea prostrata	2.82	-	-	-	-	-	-	-	-	-	-
Chorizema parvifolium	0	-	-	-	-	+	-	+	S	+	-
Cullen microcephalum	0.52	-	-	-	-	+	-	-	-	-	-
Cullen tenax	0.07	-	-	-	-	+	-	-	-	-	-
Daviesia acicularis	0	-	-	-	-	+	-	-	S	-	-
Daviesia alata	0	-	-	-	-	+	-	-	S	-	-
Daviesia buxifolia	1.65	-	-	-	-	-	-	-	-	-	-
Daviesia corymbosa	0.52	-	-	-	-	-	-	-	S	-	-
Daviesia latifolia	1.34	-	-	-	-	-	-	-	-	-	-
Daviesia leptophylla	0	-	-	-	-	+	-	-	-	-	-
Daviesia mimosoides var. *mimosoides*	4.13	-	-	-	-	-	-	-	-	-	-
Daviesia suaveolens	0.93	-	-	+	-	-	-	-	S	-	-
Daviesia ulicifolia subsp. *ulicifolia*	5.68	-	-	-	-	-	-	-	-	-	-
Daviesia ulicifolia subsp. *ruscifolia*	0	-	-	-	-	-	-	-	-	-	-
Daviesia wyattiana	0.31	-	-	-	-	+	-	-	-	-	-
Desmodium brachypodum	1.17	-	-	-	-	-	-	-	-	-	-
Desmodium gunnii	20.41	-	-	-	-	-	-	-	-	-	-
Desmodium rhytidophyllum	0	-	-	-	-	+	-	-	-	-	-
Desmodium varians	0.38	-	-	-	-	-	-	-	-	-	-
Dillwynia glaberrima	1.55	-	-	-	-	-	-	-	-	-	-
Dillwynia juniperina	0.41	-	-	-	-	+	-	-	-	-	-
Dillwynia phylicoides species complex	0.10	-	-	-	-	-	-	-	-	-	-
Dillwynia prostrata	0.03	-	-	-	-	+	-	-	-	-	-
Dillwynia ramosissima	0.03	-	-	-	-	+	-	-	-	-	-
Dillwynia sericea	1.17	-	-	-	-	-	-	-	-	-	-
Glycine clandestina species complex	29.56	-	-	-	-	-	-	-	-	-	-
Glycine tabacina species complex	1.82	-	-	-	-	-	-	-	-	-	-
Glycine sp. aff. *tomentella*	0.03	-	-	-	-	+	-	-	-	-	-
Gompholobium glabratum	0.14	-	-	-	-	-	-	-	-	-	-
Gompholobium huegelii	1.75	-	-	-	-	-	-	-	-	-	-
Gompholobium latifolium	0.41	-	-	-	-	-	-	-	-	-	-
Gompholobium minus	0.10	-	-	-	-	+	-	-	-	-	-
Gompholobium sp. B	0.07	-	-	-	-	+	-	-	-	-	-
Goodia lotifolia var. *lotifolia*	7.60	-	-	-	-	-	-	-	-	-	-
Hardenbergia violacea	14.01	-	-	-	-	-	-	-	-	-	-
Hovea linearis	2.99	-	-	-	-	-	-	-	-	-	-
Hovea longifolia	0.03	-	-	-	-	+	-	-	S	+	-
Hovea purpurea	0.65	-	-	-	-	-	-	-	-	-	-
Indigofera australis subsp. *australis*	11.70	-	-	-	-	-	-	-	-	-	-
Jacksonia scoparia	0.28	-	-	-	-	+	-	-	S	+	-
Kennedia prostrata	0.28	-	-	-	-	-	-	-	-	-	-
Kennedia rubicunda	8.95	-	-	-	-	-	-	-	-	-	-

Appendix 1 cont.	**Freq. (%)**	**1**	**2**	**3**	**4**	**5**	**5X**	**6**	**7**	**8**	**9**
Fabaceae (Faboideae) cont.											
Lespedeza juncea	0	-	-	-	-	+	-	-	-	-	-
Lotus australis	0	-	-	-	-	+	-	-	-	-	-
Mirbelia oxylobioides	0.24	-	-	-	-	-	-	-	-	-	-
Mirbelia platylobioides	0.14	-	-	-	-	-	-	-	-	-	-
Mirbelia pungens	0.03	-	-	-	-	+	-	-	-	-	-
Mirbelia rubiifolia	0.14	-	-	-	-	-	-	-	-	-	-
Oxylobium arborescens	0.96	-	-	-	-	-	-	-	-	-	-
Oxylobium ellipticum	1.17	-	-	-	-	-	-	-	-	-	-
Platylobium formosum	2.68	-	-	-	-	-	-	-	-	-	-
Podolobium alpestre	0.07	-	-	-	-	+	-	-	-	-	-
Podolobium ilicifolium	9.43	-	-	-	-	-	-	-	-	-	-
Podolobium procumbens	0.89	-	-	-	-	-	-	-	-	-	-
Podolobium scandens var. *scandens*	0	-	-	+	-	+	-	-	S	-	-
Pultenaea altissima	0.07	-	-	-	-	+	-	-	-	-	+
Pultenaea benthamii	0.76	-	-	-	-	-	-	-	N	-	-
Pultenaea blakelyi	0.03	-	-	-	-	+	-	-	S	-	-
Pultenaea capitellata	0	-	-	-	-	+	-	-	-	-	-
Pultenaea daphnoides	6.99	-	-	-	-	-	-	-	-	-	-
Pultenaea dentata	0.21	-	-	-	-	-	-	-	-	-	-
Pultenaea elliptica	0	-	-	-	-	+	-	-	S	-	-
Pultenaea hispidula	0	-	-	-	-	+	-	-	-	-	-
Pultenaea linophylla	1.10	-	-	-	-	-	-	-	-	-	-
Pultenaea paleacea var. *sericea*	0.03	-	-	-	-	+	-	-	N	-	-
Pultenaea parrisiae subsp. *parrisiae*	0	-	+	-	+	-	-	-	-	-	-
Pultenaea pedunculata	0	-	-	-	-	+	-	-	LN	-	-
Pultenaea polifolia	0.03	-	-	-	-	+	-	-	-	-	-
Pultenaea retusa	1.58	-	-	-	-	-	-	-	-	-	-
Pultenaea scabra var. *biloba*	0.65	-	-	-	-	-	-	-	-	-	-
Pultenaea scabra var. *scabra*	1.27	-	-	-	-	-	-	-	-	-	-
Pultenaea subspicata	0	-	-	-	-	+	-	-	-	-	-
Pultenaea villifera	0.31	-	-	+	-	-	-	-	S	+	-
Pultenaea villosa	0	-	-	-	-	-	-	-	-	-	-
Pultenaea viscosa	0.14	-	-	-	-	-	-	-	-	-	-
Swainsona behriana	0.03	-	-	-	-	+	-	-	-	-	-
Swainsona lessertiifolia	0	-	-	-	-	+	-	-	-	-	-
Sphaerolobium minus	0.24	-	-	-	-	-	-	-	-	-	-
Sphaerolobium vimineum	0.24	-	-	-	-	-	-	-	-	-	-
Viminaria juncea	0.10	-	-	-	-	-	-	-	-	-	-
Zornia dyctiocarpa var. *dyctiocarpa*	0.03	-	-	-	-	+	-	+	S	-	-
Fabaceae (Mimosoideae)	0										
Acacia aculeatissima	0.21	-	-	-	-	-	-	-	N	-	-
Acacia binervia	0.21	-	-	-	-	-	-	-	-	-	-
Acacia blayana	0.14	+	-	+	-	-	-	-	-	-	-
Acacia brownii	0.14	-	-	-	-	-	-	-	-	-	-
Acacia cognata	2.89	-	-	-	-	-	-	-	-	-	-
Acacia constablei	0	+	+	-	-	-	-	-	-	-	-
Acacia costiniana	0.10	-	-	+	+	-	-	-	S	+	-
Acacia covenyi	0	-	-	+	-	-	-	-	S	+	-
Acacia dawsonii	0.03	-	-	-	-	-	-	+	-	-	-
Acacia dealbata subsp. *dealbata*	10.08	-	-	-	-	-	-	-	-	-	-
Acacia dealbata subsp. *subalpina*	0	-	-	-	-	-	-	-	-	-	-
Acacia deanei subsp. *paucijuga*	0.07	-	-	-	-	+	-	-	-	-	-

Appendix 1 cont.	**Freq. (%)**	**1**	**2**	**3**	**4**	**5**	**5X**	**6**	**7**	**8**	**9**
Fabaceae (Mimosoideae) cont.											
Acacia elongata	0.07	-	-	-	-	+	-	-	S	-	-
Acacia falciformis	20.20	-	-	-	-	-	-	-	-	-	-
Acacia floribunda	1.62	-	-	-	-	-	-	-	-	-	-
Acacia genistifolia	0.17	-	-	-	-	-	-	-	-	-	-
Acacia georgensis	0	+	+	-	-	-	-	-	-	-	-
Acacia gunnii	0.41	-	-	-	-	+	-	-	-	-	-
Acacia implexa	3.68	-	-	-	-	-	-	-	-	-	-
Acacia irrorata subsp. *irrorata*	3.20	-	-	-	-	-	-	-	LS	-	-
Acacia kybeanensis	0.10	-	-	-	-	-	-	-	-	-	-
Acacia kydrensis	0.17	-	-	+	+	-	-	-	S	-	-
Acacia lanigera var. *gracilipes*	0.07	-	-	-	-	+	-	-	N	-	-
Acacia leprosa	0	-	-	-	-	+	-	-	-	-	-
Acacia longifolia	11.46	-	-	-	-	-	-	-	-	-	-
Acacia lucasii	0.24	-	-	+	-	-	-	-	LS	-	-
Acacia mabellae	0.03	-	-	-	-	+	-	-	S	-	-
Acacia maidenii	0.69	-	-	-	-	-	-	-	-	-	-
Acacia mearnsii	15.07	-	-	-	-	-	-	-	-	-	-
Acacia melanoxylon	8.16	-	-	-	-	-	-	-	-	-	-
Acacia mucronata var. *longifolia*	5.02	-	-	-	-	-	-	-	N	-	-
Acacia myrtifolia	3.85	-	-	-	-	-	-	-	-	-	-
Acacia obliquinervia	2.51	-	-	-	-	-	-	-	-	-	-
Acacia obtusifolia	10.98	-	-	-	-	-	-	-	-	-	-
Acacia oxycedrus	0.03	-	-	-	-	+	-	-	LN	-	-
Acacia paradoxa	0	-	-	-	-	-	+	-	-	-	-
Acacia penninervis	0.89	-	-	-	-	-	-	-	-	-	-
Acacia pycnantha	0.03	-	-	-	-	+	-	-	-	-	+
Acacia rubida	1.03	-	-	-	-	-	-	-	-	-	-
Acacia siculiformis	0.10	-	-	-	-	-	-	-	-	-	-
Acacia silvestris	0.86	-	-	-	-	-	-	-	LS	-	-
Acacia sophorae	1.93	-	-	-	-	-	-	-	-	-	-
Acacia stricta	0.69	-	-	-	-	-	-	-	-	-	-
Acacia suaveolens	1.51	-	-	-	-	-	-	-	-	-	-
Acacia subporosa	2.31	-	-	-	+	-	-	-	N	-	-
Acacia subtilinervis	0.07	-	-	+	-	-	-	-	-	+	-
Acacia terminalis subsp. *angustifolia*	11.63	-	-	-	-	-	-	-	-	-	-
Acacia ulicifolia	1.82	-	-	-	-	-	-	-	-	-	-
Acacia verniciflua	0.41	-	-	-	-	-	-	-	-	-	-
Acacia verticillata var. *verticillata*	0.45	-	-	-	-	-	-	-	N	-	-
Gentianaceae											
Chionogentias cunninghamii subsp. *cunninghamii*	0.21	-	-	-	-	-	-	-	-	-	-
Sebaea ovata	0	-	-	-	-	-	+	-	-	-	-
Geraniaceae											
Geranium antrorsum	0.17	-	-	-	-	-	-	-	-	-	-
Geranium homeanum	2.13	-	-	-	-	-	-	-	-	-	-
Geranium neglectum	0.55	-	-	-	-	-	-	-	-	-	-
Geranium potentilloides var. *potentilloides*	12.80	-	-	-	-	-	-	-	-	-	-
Geranium retrorsum	0.10	-	-	-	-	+	-	-	-	-	-
Geranium solanderi var. *solanderi*	7.40	-	-	-	-	-	-	-	-	-	-
Pelargonium australe subsp. *australe*	0.65	-	-	-	-	-	-	-	-	-	-
Pelargonium inodorum	0.69	-	-	-	-	-	-	-	-	-	-

Appendix 1 cont.	**Freq. (%)**	**1**	**2**	**3**	**4**	**5**	**5X**	**6**	**7**	**8**	**9**
Gesneriaceae											
Fieldia australis	1.48	-	-	-	-	-	-	-	-	-	-
Goodeniaceae											
Coopernookia barbata	1.75	-	-	-	-	-	-	-	-	-	-
Dampiera fusca	0.14	-	-	+	-	-	-	-	LN	+	-
Dampiera stricta	3.06	-	-	-	-	-	-	-	-	-	-
Goodenia bellidifolia subsp. *bellidifolia*	0.14	-	-	-	-	-	-	-	-	-	-
Goodenia elongata	0.17	-	-	-	-	-	-	-	N	-	-
Goodenia hederacea var. *alpestris*	0.45	-	-	-	-	+	-	-	-	-	-
Goodenia hederacea var. *hederacea*	0.10	-	-	-	-	+	-	-	S	-	-
Goodenia heterophylla subsp. *eglandulosa*	0.03	-	-	-	-	+	-	-	S	-	-
Goodenia humilis	0.03	-	-	-	-	+	-	-	N	-	-
Goodenia ovata	17.86	-	-	-	-	-	-	-	-	-	-
Goodenia paniculata	0.14	-	-	-	-	+	-	-	-	-	-
Goodenia stelligera	0.10	-	-	-	-	+	-	-	-	-	-
Scaevola aemula	0.28	-	-	-	-	-	-	-	-	-	-
Scaevola albida	0.07	-	-	-	-	+	-	-	-	-	-
Scaevola calendulacea	0.07	-	-	-	-	+	-	-	-	-	-
Scaevola hookeri	0	-	-	-	-	-	-	-	-	-	-
Scaevola ramosissima	2.00	-	-	-	-	-	-	-	-	-	-
Selliera radicans	1.07	-	-	-	-	-	-	-	-	-	-
Velleia montana	0.03	-	-	-	-	+	-	-	-	-	-
Velleia paradoxa	0	-	-	-	-	+	-	-	-	-	-
Haloragaceae											
Gonocarpus humilis	0.03	-	-	-	-	+	-	-	-	-	-
Gonocarpus micranthus	1.03	-	-	-	-	-	-	-	-	-	-
Gonocarpus tetragynus	11.67	-	-	-	-	-	-	-	-	-	-
Gonocarpus teucrioides	28.53	-	-	-	-	-	-	-	-	-	-
Haloragis heterophylla	0.17	-	-	-	-	+	-	-	-	-	-
Haloragodendron baeuerlenii	0.03	-	-	+	-	-	-	-	-	-	-
Haloragodendron monospermum	0.28	-	-	+	-	-	-	-	S	-	-
Myriophyllum caput-medusae	0	-	-	-	-	+	-	-	-	-	-
Myriophyllum pedunculatum subsp. *pedunculatum*	0.07	-	-	-	-	+	-	-	-	-	-
Myriophyllum propinquum	0.03	-	-	-	-	+	-	-	-	-	-
Myriophyllum simulans	0	-	-	-	-	+	-	-	-	-	-
Myriophyllum variifolium	0.07	-	-	-	-	-	-	-	-	-	-
Myriophyllum verrucosum	0	-	-	-	-	+	-	-	-	-	-
Lamiaceae											
Ajuga australis	3.13	-	-	-	-	-	-	-	-	-	-
Lycopus australis	0.21	-	-	-	-	-	-	-	-	-	-
Mentha diemenica	0.58	-	-	-	-	-	-	-	-	-	-
Mentha laxiflora	0	-	-	-	-	+	-	-	-	-	-
Mentha satureioides	0.28	-	-	-	-	-	-	-	-	-	-
Plectranthus graveolens	0.55	-	-	-	-	-	-	-	S	+	-
Plectranthus parviflorus	6.06	-	-	-	-	-	-	-	-	-	-
Prostanthera decussata	0	-	-	-	-	+	-	-	N	-	-
Prostanthera denticulata s.lat.	0	-	-	-	-	+	-	-	-	-	-
Prostanthera hirtula	0	-	-	-	-	-	-	-	S	-	-
Prostanthera incana	0.34	-	-	-	-	-	-	-	-	-	-
Prostanthera incisa	1.89	-	-	-	-	-	-	-	S	-	-
Prostanthera lasianthos	4.85	-	-	-	-	-	-	-	-	-	-
Prostanthera linearis	0	-	-	-	-	+	-	-	S	-	-

Appendix 1 cont.	Freq. (%)	1	2	3	4	5	5X	6	7	8	9
Lamiaceae cont.											
Prostanthera melissifolia	0.10	-	-	-	-	-	-	-	-	-	-
Prostanthera nivea var. *nivea*	0	-	-	-	-	+	-	-	-	-	-
Prostanthera ovalifolia	0.10	-	-	-	-	-	-	-	-	-	-
Prostanthera phylicifolia	0.03	-	-	-	-	+	-	-	-	-	-
Prostanthera rotundifolia	0.14	-	-	-	-	-	-	-	-	-	-
Prostanthera saxicola var. *montana*	0	-	-	-	-	+	-	-	S	-	-
Prostanthera scutellarioides	0	-	-	-	-	+	-	-	S	-	-
Prostanthera violacea	0.07	-	-	-	-	+	-	-	-	-	-
Prostanthera walteri	0	-	-	+	-	-	-	-	N	-	-
Scutellaria humilis	0.24	-	-	-	-	-	-	-	-	-	-
Scutellaria mollis	0.45	-	-	-	-	-	-	-	-	-	-
Teucrium corymbosum	0.10	-	-	-	-	-	-	-	-	-	-
Westringia davidii	0.14	+	+	-	-	-	-	-	-	-	-
Westringia eremicola	0.31	-	-	-	-	-	-	-	-	-	-
Westringia fruticosa	0.45	-	-	-	-	-	-	-	S	-	-
Westringia kydrensis	0	+	+	-	-	-	-	-	-	-	-
Lauraceae											
Cassytha glabella	2.27	-	-	-	-	-	-	-	-	-	-
Cassytha melantha	0.21	-	-	-	-	-	-	-	-	-	-
Cassytha pubescens	4.78	-	-	-	-	-	-	-	-	-	-
Cryptocarya glaucescens	0	-	-	-	-	+	-	-	S	-	-
Cryptocarya microneura	0	-	-	-	-	+	-	-	S	+	-
Lentibulariaceae											
Utricularia dichotoma	0.31	-	-	-	-	-	-	-	-	-	-
Utricularia lateriflora	0.03	-	-	-	-	+	-	-	-	-	-
Utricularia monanthos	0	-	-	-	-	+	-	-	-	-	-
Linaceae											
Linum marginale	0.07	-	-	-	-	+	-	-	-	-	-
Lobeliaceae											
Isotoma axillaris	0.34	-	-	-	-	-	-	-	-	-	-
Lobelia alata	0.93	-	-	-	-	-	-	-	-	-	-
Lobelia dentata	0.21	-	-	-	-	-	-	-	S	-	-
Lobelia gibbosa	0.07	-	-	-	-	+	-	-	-	-	-
Pratia pedunculata	0.34	-	-	-	-	-	-	-	-	-	-
Pratia puberula	0	-	-	-	-	+	-	-	-	-	-
Pratia purpurascens	10.43	-	-	-	-	-	-	-	-	-	-
Pratia surrepens	0.10	-	-	-	-	-	-	-	-	-	-
Loganiaceae											
Logania albiflora	1.14	-	-	-	-	-	-	-	-	-	-
Logania pusilla	0.34	-	-	-	-	-	-	-	-	-	-
Mitrasacme pilosa	0.07	-	-	-	-	+	-	-	-	-	-
Mitrasacme polymorpha	0.55	-	-	-	-	-	-	-	-	-	-
Mitrasacme serpyllifolia	0.21	-	-	+	-	-	-	-	-	-	-
Loranthaceae											
Amyema cambagei	0	-	-	-	-	+	-	-	S	-	-
Amyema congener subsp. *congener*	0.24	-	-	-	-	-	-	-	S	-	-
Amyema miquelii	0.03	-	-	-	-	+	-	-	-	-	-
Amyema pendulum subsp. *pendulum*	1.62	-	-	-	-	-	-	-	-	-	-
Muellerina eucalyptoides	0.76	-	-	-	-	-	-	-	-	-	-
Lythraceae											
Lythrum hyssopifolia	0.10	-	-	-	-	-	-	-	-	-	-
Lythrum salicaria	0.24	-	-	-	-	-	-	-	-	-	-

Appendix 1 cont.	**Freq. (%)**	**1**	**2**	**3**	**4**	**5**	**5X**	**6**	**7**	**8**	**9**
Malvaceae											
Abutilon oxycarpum	0.14	-	-	-	-	-	-	-	-	-	-
Gynatrix pulchella	0.10	-	-	-	-	-	-	-	-	-	-
Howittia trilocularis	0.48	-	-	-	-	-	-	-	-	-	-
Meliaceae											
Synoum glandulosum	2.37	-	-	-	-	-	-	-	S	-	-
Menispermaceae											
Sarcopetalum harveyanum	3.30	-	-	-	-	-	-	-	-	-	-
Stephania japonica var. *discolor*	2.55	-	-	-	-	-	-	-	S	-	-
Menyanthaceae											
Nymphoides montana	0	-	-	-	-	+	-	-	-	-	-
Villarsia exaltata	0.10	-	-	-	-	+	-	-	-	-	-
Villarsia reniformis	0.17	-	-	-	-	+	-	-	-	-	-
Monimiaceae											
Atherosperma moschatum	0.10	-	-	-	-	+	-	-	-	-	-
Doryphora sassafras	0.69	-	-	-	-	-	-	-	S	-	-
Hedycarya angustifolia	3.06	-	-	-	-	-	-	-	-	-	-
Moraceae											
Ficus coronata	0.52	-	-	-	-	-	-	-	-	-	-
Ficus obliqua	0	-	-	-	-	+	-	-	S	-	-
Ficus rubiginosa	0.89	-	-	-	-	-	-	-	S	-	-
Myoporaceae											
Myoporum acuminatum	0.48	-	-	-	-	-	-	-	S	-	-
Myoporum boninense subsp. *australe*	0	-	-	-	-	+	-	-	S	-	-
Myoporum bateae	0.03	-	-	+	-	-	-	-	S	-	-
Myoporum montanum	0	-	-	-	-	+	-	-	-	-	-
Myoporum insulare	0.21	-	-	-	-	-	-	-	-	-	-
Myrsinaceae											
Aegiceras corniculatum	0.31	-	-	-	-	+	-	-	S	-	-
Rapanea howittiana	3.03	-	-	-	-	-	-	-	-	-	-
Myrtaceae											
Acmena smithii	3.75	-	-	-	-	-	-	-	-	-	-
Angophora floribunda	11.80	-	-	-	-	-	-	-	-	-	-
Backhousia myrtifolia	0.76	-	-	-	-	-	-	-	S	-	-
Baeckea denticulata	0.28	-	-	+	-	-	-	-	S	-	-
Baeckea linifolia	0.31	-	-	-	-	-	-	-	-	-	-
Baeckea ramosissima subsp. *prostrata*	0	-	-	-	-	+	-	-	-	-	-
Baeckea utilis	0.79	-	-	-	-	-	-	-	-	-	-
Babingtonia virgata	2.82	-	-	-	-	-	-	-	-	-	-
Callistemon citrinus	0.69	-	-	-	-	-	-	-	-	-	-
Callistemon pallidus	0.55	-	-	-	-	-	-	-	S	-	-
Callistemon pityoides	0.07	-	-	-	-	+	-	-	-	-	-
Callistemon sieberi	0	-	-	-	-	+	-	-	-	-	-
Callistemon subulatus	0.45	-	-	-	-	-	-	-	-	-	-
Calytrix tetragona	0.41	-	-	-	-	-	-	-	-	-	-
Corymbia gummifera	6.30	-	-	-	-	-	-	-	-	-	-
Corymbia maculata	0.41	-	-	-	-	-	-	-	LS	-	-
Darwinia camptostylis	0.28	-	-	-	-	-	-	-	-	-	-
Eucalyptus agglomerata	12.80	-	-	-	-	-	-	-	-	-	-
Eucalyptus amplifolia subsp. *amplifolia*	0	-	-	-	-	+	-	-	S	+	-
Eucalyptus angophoroides	5.92	-	-	-	-	-	-	-	-	-	-
Eucalyptus badjensis	0.58	-	-	+	+	-	-	-	S	-	-

Appendix 1 cont.	**Freq. (%)**	**1**	**2**	**3**	**4**	**5**	**5X**	**6**	**7**	**8**	**9**
Myrtaceae cont.											
Eucalyptus baueriana	2.82	-	-	-	-	-	-	+	-	-	-
Eucalyptus baeuerlenii	0	-	-	+	-	-	-	-	S	+	-
Eucalyptus baxteri	0.86	-	-	-	-	-	-	-	N	-	-
Eucalyptus blaxlandii	0.03	-	-	-	-	+	-	-	S	-	-
Eucalyptus bosistoana	6.61	-	-	-	-	-	-	-	-	-	-
Eucalyptus botryoides	1.31	-	-	-	-	-	-	-	-	-	-
Eucalyptus bridgesiana	0.03	-	-	-	-	-	-	-	-	-	-
Eucalyptus camphora subsp. *humeana*	0	-	-	-	-	-	-	-	-	-	-
Eucalyptus cephalocarpa	0.03	-	-	+	-	-	-	-	N	-	-
Eucalyptus consideniana	2.89	-	-	-	-	-	-	-	-	-	-
Eucalyptus conspicua	0.07	-	-	+	-	-	-	-	N	-	-
Eucalyptus croajingolensis	0.14	-	-	-	-	-	-	-	N	-	-
Eucalyptus cypellocarpa	26.98	-	-	-	-	-	-	-	-	-	-
Eucalyptus dalrympleana subsp. *dalrympleana*	2.48	-	-	-	-	-	-	-	-	-	-
Eucalyptus denticulata	0.03	-	-	-	-	+	-	-	-	-	-
Eucalyptus dives	1.45	-	-	-	-	-	-	-	-	-	-
Eucalyptus elata	10.32	-	-	-	-	-	-	-	-	-	-
Eucalyptus eugenioides	0.07	-	-	-	-	-	-	-	S	-	-
Eucalyptus fastigata	11.11	-	-	-	-	-	-	-	-	-	-
Eucalyptus fraxinoides	2.96	-	-	-	-	-	-	-	-	-	-
Eucalyptus globoidea	24.74	-	-	-	-	-	-	-	-	-	-
Eucalyptus gregsoniana	0	-	-	+	-	-	-	-	S	-	-
Eucalyptus ignorabilis	0.03	-	-	+	-	-	-	-	N	-	-
Eucalyptus imlayensis	0	+	+	-	-	-	-	-	-	-	-
Eucalyptus kybeanensis	0.31	-	-	-	-	-	-	-	-	-	-
Eucalyptus latiuscula	0.14	-	-	+	-	-	-	-	S	-	-
Eucalyptus longifolia	7.43	-	-	-	-	-	-	-	S	-	-
Eucalyptus mackintii	0.24	-	-	-	-	+	-	-	N	-	-
Eucalyptus macrorhyncha	0.03	-	-	-	-	-	-	-	-	-	-
Eucalyptus maidenii	5.30	-	-	-	-	-	-	-	-	-	+
Eucalyptus mannifera	0.31	-	-	-	-	-	-	-	-	-	-
Eucalyptus melliodora	0.58	-	-	-	-	-	-	+	-	-	+
Eucalyptus muelleriana	17.14	-	-	-	-	-	-	-	-	-	-
Eucalyptus nitens	1.27	-	-	-	-	-	-	-	-	-	-
Eucalyptus obliqua	13.80	-	-	-	-	-	-	-	-	-	-
Eucalyptus olsenii	0	-	-	+	-	-	-	-	-	-	-
Eucalyptus ovata	2.24	-	-	-	-	-	-	-	-	-	-
Eucalyptus paliformis	0.03	+	-	+	-	-	-	-	-	-	-
Eucalyptus paniculata subsp. *paniculata*	0.10	-	-	-	-	-	-	-	S	-	-
Eucalyptus parvula	0.07	-	+	-	+	-	-	-	S	-	-
Eucalyptus pauciflora	2.44	-	-	-	-	-	-	-	-	-	-
Eucalyptus perriniana	0	-	-	-	-	+	-	-	-	-	-
Eucalyptus pilularis	0.24	-	-	-	-	-	-	-	S	-	-
Eucalyptus polyanthemos subsp. *vestita*	1.93	-	-	-	-	-	-	-	LN	-	-
Eucalyptus pseudoglobulus	0.07	-	-	-	-	+	-	-	N	-	-
Eucalyptus radiata subsp. *radiata*	8.47	-	-	-	-	-	-	-	-	-	-
Eucalyptus rubida subsp. *rubida*	0.65	-	-	-	-	-	-	-	-	-	-
Eucalyptus sieberi	28.66	-	-	-	-	-	-	-	-	-	-
Eucalyptus smithii	4.71	-	-	-	-	-	-	-	-	-	-
Eucalyptus sp. aff. *globoidea*	0	-	-	+	+	-	-	-	N	-	-
Eucalyptus sp. aff. *radiata*	1.79	-	-	-	-	-	-	-	-	-	-

Appendix 1 cont.	**Freq. (%)**	**1**	**2**	**3**	**4**	**5**	**5X**	**6**	**7**	**8**	**9**
Myrtaceae cont.											
Eucalyptus spectatrix	0	+	-	+	-	-	-	-	-	-	-
Eucalyptus stellulata	0.38	-	-	-	-	-	-	-	-	-	-
Eucalyptus stenostoma	0.45	-	-	-	-	-	-	-	S	-	-
Eucalyptus tereticornis	2.41	-	-	-	-	-	-	+	-	-	-
Eucalyptus tricarpa	4.20	-	-	-	-	-	-	-	-	-	-
Eucalyptus viminalis	5.78	-	-	-	-	-	-	-	-	-	-
Eucalyptus wilcoxii	0	-	-	+	-	-	-	-	S	-	-
Eucalyptus yangoura	0	-	-	-	-	-	-	-	N	-	-
Kunzea ambigua	2.51	-	-	-	-	-	-	-	-	-	-
Kunzea ericoides	3.27	-	-	-	-	-	-	-	-	-	-
Kunzea parvifolia	0.14	-	-	-	-	+	-	-	-	-	-
Kunzea sp. C	0.62	-	-	-	-	-	-	-	S	-	-
Leptospermum brevipes	0.28	-	-	-	-	-	-	-	-	-	-
Leptospermum continentale	5.51	-	-	-	-	-	-	-	-	-	-
Leptospermum emarginatum	0.62	-	-	-	-	-	-	-	-	-	-
Leptospermum grandifolium	0.14	-	-	-	-	-	-	-	-	-	-
Leptospermum laevigatum	0.72	-	-	-	-	-	-	-	LN	-	-
Leptospermum lanigerum	1.17	-	-	-	-	-	-	-	-	-	-
Leptospermum morrisonii	0.10	-	-	-	-	-	-	-	S	-	-
Leptospermum myrsinoides	0.24	-	-	-	-	-	-	-	N	-	-
Leptospermum myrtifolium	0.65	-	-	-	-	-	-	-	-	-	-
Leptospermum obovatum	0.10	-	-	-	-	-	-	-	-	-	-
Leptospermum polygalifolium subsp. *polygalifolium*	0.24	-	-	-	-	-	-	-	S	-	-
Leptospermum rotundifolium	0	-	-	-	-	+	-	-	S	+	-
Leptospermum scoparium	1.34	-	-	-	-	-	-	-	N	-	-
Leptospermum trinervium	2.96	-	-	-	-	-	-	-	-	-	-
Melaleuca armillaris	2.82	-	-	-	-	-	-	-	-	-	-
Melaleuca ericifolia	0.72	-	-	-	-	-	-	-	-	-	-
Melaleuca hypericifolia	0.24	-	-	-	-	-	-	-	S	-	-
Melaleuca parvistaminea	0	-	-	-	-	-	-	-	-	-	-
Melaleuca squarrosa	1.17	-	-	-	-	-	-	-	-	-	-
Micromyrtus ciliata	0	-	-	-	-	+	-	-	-	-	-
Syzygium australe	0	-	-	-	-	+	-	-	S	+	-
Tristaniopsis collina	0.10	-	-	-	-	+	-	-	S	-	-
Tristaniopsis laurina	0.38	-	-	-	-	-	-	-	-	-	-
Olacaceae											
Olax stricta	0	-	-	-	-	+	-	-	-	-	-
Oleaceae											
Nestegis ligustrina	0.34	-	-	-	-	-	-	-	-	-	-
Notelaea longifolia forma *longifolia*	0.10	-	-	-	-	+	-	-	S	-	-
Notelaea venosa	13.76	-	-	-	-	-	-	-	-	-	-
Onagraceae											
Epilobium billardierianum subsp. *billardierianum*	0.28	-	-	-	-	-	-	-	-	-	-
Epilobium billardierianum subsp. *cinereum*	1.31	-	-	-	-	-	-	-	-	-	-
Epilobium billardierianum subsp. *hydrophilum*	0.45	-	-	-	-	-	-	-	-	-	-
Epilobium gunnianum	0.28	-	-	-	-	-	-	-	-	-	-
Epilobium pallidiflorum	0	-	-	+	-	-	-	+	-	-	-
Ludwigia peploides subsp. *montevidensis*	0	-	-	-	-	-	-	-	-	-	-

Appendix 1 cont.	Freq. (%)	1	2	3	4	5	5X	6	7	8	9
Oxalidaceae											
Oxalis chnoodes	2.20	-	-	-	-	-	-	-	-	-	-
Oxalis exilis	0.65	-	-	-	-	-	-	-	-	-	-
Oxalis perennans	14.66	-	-	-	-	-	-	-	-	-	-
Oxalis rubens	0.03	-	-	-	-	+	-	-	-	-	-
Oxalis thompsoniae	0	-	-	-	-	-	-	-	-	-	-
Passifloraceae											
Passiflora cinnabarina	1.00	-	-	-	-	-	-	-	-	-	-
Pittosporaceae											
Billardiera longiflora	0.21	-	-	-	-	-	-	-	-	-	-
Billardiera scandens var. *scandens*	27.67	-	-	-	-	-	-	-	-	-	-
Bursaria lasiophylla	3.06	-	-	-	-	-	-	-	-	-	-
Bursaria spinosa	9.29	-	-	-	-	-	-	-	-	-	-
Citriobatus pauciflorus	0.83	-	-	-	-	-	-	-	S	-	-
Pittosporum bicolor	0.72	-	-	-	-	-	-	-	-	-	-
Pittosporum revolutum	4.75	-	-	-	-	-	-	-	-	-	-
Pittosporum undulatum	9.74	-	-	-	-	-	-	-	-	-	-
Rhytidosporum procumbens	2.10	-	-	-	-	-	-	-	-	-	-
Plantaginaceae											
Plantago debilis	8.29	-	-	-	-	-	-	-	-	-	-
Plantago hispida	0.03	-	-	-	-	+	-	-	-	-	-
Plantago varia	2.27	-	-	-	-	-	-	-	-	-	-
Plumbaginaceae											
Limonium australe	0.89	-	-	+	-	-	-	-	-	-	-
Polygalaceae											
Comesperma defoliatum	0.21	-	-	-	-	-	-	-	-	-	-
Comesperma ericinum	1.14	-	-	-	-	-	-	-	-	-	-
Comesperma retusum	0.07	-	-	-	-	+	-	-	-	-	-
Comesperma sphaerocarpa	0	-	-	-	-	+	-	-	S	-	-
Comesperma volubile	4.71	-	-	-	-	-	-	-	-	-	-
Polygala japonica	0.03	-	-	-	-	+	-	+	-	-	-
Polygonaceae											
Muehlenbeckia adpressa	0.86	-	-	-	-	-	-	-	N	-	-
Muehlenbeckia gracillima	0.07	-	-	-	-	+	-	-	S	-	-
Muehlenbeckia rhyticarya	0	-	-	-	-	+	-	-	-	-	-
Persicaria decipiens	0.31	-	-	-	-	-	-	-	-	-	-
Persicaria hydropiper	0.03	-	-	-	-	-	-	-	-	-	-
Persicaria lapathifolia	0	-	-	-	-	+	-	-	-	-	-
Persicaria praetermissa	0.10	-	-	-	-	+	-	-	-	-	-
Persicaria prostrata	0	-	-	-	-	+	-	-	-	-	-
Persicaria subsessilis	0	-	-	-	-	+	-	-	-	-	-
Rumex brownii	3.44	-	-	-	-	-	-	-	-	-	-
Rumex tenax	0	-	-	-	-	+	-	-	-	-	-
Portulacaceae											
Calandrinia calyptrata	0.07	-	-	-	-	+	-	-	-	-	-
Calandrinia pickeringii	0	-	-	-	-	+	-	-	S	-	-
Neopaxia australasica	0.07	-	-	-	-	-	-	-	-	-	+
Primulaceae											
Lysimachia japonica	0.03	-	-	-	-	+	-	-	-	-	-
Samolus repens	1.86	-	-	-	-	-	-	-	-	-	-
Samolus valerandii	0	-	-	-	-	+	-	-	-	-	-

Appendix 1 cont.	**Freq. (%)**	**1**	**2**	**3**	**4**	**5**	**5X**	**6**	**7**	**8**	**9**
Proteaceae											
Banksia canei	1.27	-	-	-	-	-	-	-	-	-	-
Banksia cunninghamii subsp. *cunninghamii*	0.17	-	-	-	-	-	-	-	LN	-	-
Banksia integrifolia subsp. *integrifolia*	2.27	-	-	-	-	-	-	-	-	-	-
Banksia marginata	3.72	-	-	-	-	-	-	-	-	-	-
Banksia paludosa	0.79	-	-	-	-	-	-	-	S	-	-
Banksia serrata	3.58	-	-	-	-	-	-	-	-	-	-
Banksia spinulosa var. *spinulosa*	1.62	-	-	-	-	-	-	-	S	-	-
Conospermum taxifolium	0.24	-	-	-	-	-	-	-	-	-	-
Grevillea acanthifolia subsp. *paludosa*	0	+	+	-	-	-	-	-	-	-	-
Grevillea baueri	0.03	-	-	-	-	+	-	-	S	-	-
Grevillea lanigera	0.58	-	-	-	-	-	-	-	-	-	-
Grevillea linearifolia form `g' *sensu* McGillivray	0.10	-	-	-	-	-	-	-	-	-	-
Grevillea mucronulata	0	-	-	-	-	+	-	-	S	+	-
Grevillea oxyantha subsp. *oxyantha*	0.1	-	-	-	-	+	-	-	S	-	-
Grevillea victoriae var. *leptoneura*	0.62	-	-	-	-	-	-	-	N	-	-
Grevillea sp. (*irrassa* subsp. *irrassa* ms)	0.31	+	-	+	-	-	-	-	-	-	-
Grevillea sp. (*irrassa* subsp.*didymochiton* ms)	0	-	-	+	+	-	-	-	S	-	-
Hakea dactyloides	1.51	-	-	-	-	-	-	-	-	-	-
Hakea decurrens subsp. *physocarpa*	0.24	-	-	-	-	-	-	-	N	-	-
Hakea decurrens subsp. *platytaena*	0	-	-	-	-	+	-	-	N	-	-
Hakea eriantha	5.30	-	-	-	-	-	-	-	-	-	-
Hakea macraeana	3.72	-	-	-	-	-	-	-	S	-	-
Hakea microcarpa	0.58	-	-	-	-	-	-	-	-	-	-
Hakea sericea	1.72	-	-	-	-	-	-	-	S	-	-
Hakea teretifolia	0.45	-	-	-	-	-	-	-	-	-	-
Hakea ulicina	0.28	-	-	-	-	-	-	-	N	-	-
Isopogon prostratus	0.34	-	-	+	-	-	-	-	-	-	-
Lomatia fraseri	2.37	-	-	-	-	-	-	-	-	-	-
Lomatia ilicifolia	10.01	-	-	-	-	-	-	-	-	-	-
Lomatia myricoides	6.33	-	-	-	-	-	-	-	-	-	-
Persoonia asperula	0.93	-	-	-	-	+	-	-	S?	-	-
Persoonia brevifolia	0.58	-	-	+	+	-	-	-	N	-	-
Persoonia chamaepeuce	0.93	-	-	-	-	-	-	-	-	-	-
Persoonia confertiflora	0.96	-	-	-	-	-	-	-	-	-	-
Persoonia juniperina	0.28	-	-	-	-	-	-	-	N	-	-
Persoonia levis	2.03	-	-	-	-	-	-	-	-	-	-
Persoonia linearis	31.45	-	-	-	-	-	-	-	-	-	-
Persoonia rigida	0.10	-	-	-	-	-	-	-	-	-	-
Persoonia silvatica	4.20	-	-	-	-	-	-	-	-	-	-
Symphionema paludosum	0.24	-	-	-	-	-	-	-	S	+	-
Telopea oreades	0.45	-	-	-	-	-	-	-	-	-	-
Ranunculaceae											
Clematis aristata	29.63	-	-	-	-	-	-	-	-	-	-
Clematis glycinoides var. *glycinoides*	6.47	-	-	-	-	-	-	-	-	-	-
Clematis microphylla var. *leptophylla*	0.14	-	-	-	-	+	-	-	-	-	-
Ranunculus amphitrichus	0.03	-	-	-	-	-	-	-	-	-	-
Ranunculus collinus	0.03	-	-	-	-	+	-	-	-	-	-
Ranunculus diminutus	0	-	-	-	-	+	-	-	-	-	-
Ranunculus inundatus	0.28	-	-	-	-	-	-	-	-	-	-
Ranunculus lappaceus	1.24	-	-	-	-	-	-	-	-	-	-

Appendix 1 cont.	**Freq. (%)**	**1**	**2**	**3**	**4**	**5**	**5X**	**6**	**7**	**8**	**9**
Ranunculaceae cont.											
Ranunculus papulentus	0	-	-	-	-	+	-	-	-	-	-
Ranunculus pimpinellifolius	0.17	-	-	-	-	+	-	-	-	-	-
Ranunculus plebeius	3.92	-	-	-	-	-	-	-	-	-	-
Ranunculus scapiger	0.17	-	-	-	-	-	-	-	-	-	-
Rhamnaceae											
Cryptandra amara var. *amara*	0.03	-	-	-	-	+	-	-	-	-	-
Cryptandra amara var. *longiflora*	0.03	-	-	-	-	+	-	-	-	-	-
Cryptandra ericoides	0.24	-	-	-	-	-	-	-	-	-	-
Cryptandra propinqua	0	-	-	-	-	+	-	-	-	-	-
Cryptandra scortechinii	0	-	-	-	-	+	-	-	S	-	-
Discaria pubescens	0.10	-	-	+	-	-	-	-	-	-	-
Pomaderris andromedifolia subsp. *andromedifolia*	0.10	-	-	-	-	-	-	-	-	-	-
Pomaderris andromedifolia subsp. *confusa*	0	-	-	+	-	-	-	-	S	-	-
Pomaderris angustifolia	0.03	-	-	-	-	+	-	-	-	-	-
Pomaderris aspera	13.66	-	-	-	-	-	-	-	-	-	-
Pomaderris betulina	0.10	-	-	-	-	+	-	-	-	-	-
Pomaderris bodalla	0	-	-	+	-	-	-	-	S	-	-
Pomaderris brogoensis	0.48	-	-	+	+	-	-	-	S	-	-
Pomaderris cinerea	1.41	-	-	-	-	-	-	-	S	-	-
Pomaderris costata	0.10	-	-	+	-	-	-	-	-	-	-
Pomaderris cotoneaster	0.03	-	+	-	-	-	-	-	-	-	-
Pomaderris discolor	0.07	-	-	-	-	+	-	-	-	-	-
Pomaderris elachophylla	0.03	-	+	-	-	+	-	-	LN	-	-
Pomaderris elliptica	0.52	-	-	-	-	-	-	-	-	-	-
Pomaderris eriocephala	0.07	-	-	-	-	+	-	-	-	-	-
Pomaderris ferruginea	0.45	-	-	-	-	-	-	-	-	-	-
Pomaderris intermedia	0.21	-	-	-	-	-	-	-	-	-	-
Pomaderris lanigera	1.72	-	-	-	-	-	-	-	-	-	-
Pomaderris ledifolia	0.10	-	-	-	-	+	-	-	-	-	-
Pomaderris ligustrina	0.24	-	-	-	-	-	-	-	-	-	-
Pomaderris pallida	0	-	+	-	-	-	-	-	-	-	-
Pomaderris parrisiae	0	-	+	-	+	-	-	-	S	-	-
Pomaderris pauciflora	0.03	-	-	+	-	-	-	-	-	-	-
Pomaderris phylicifolia var. *ericoides*	0	-	-	-	-	+	-	-	-	-	-
Pomaderris pilifera	0	-	-	-	-	+	-	-	-	-	-
Pomaderris prunifolia	0.07	-	-	-	-	+	-	-	-	-	-
Pomaderris virgata	0	-	-	+	+	-	-	-	S	-	-
Spyridium cinereum	0.03	-	-	+	-	-	-	-	-	-	-
Spyridium parvifolium	0.07	-	-	-	-	-	-	-	-	-	-
Rosaceae											
Acaena agnipila	0.14	-	-	-	-	-	-	-	-	-	-
Acaena echinata	1.07	-	-	-	-	-	-	-	-	-	-
Acaena novae-zelandiae	9.53	-	-	-	-	-	-	-	-	-	-
Acaena ovina	0.34	-	-	-	-	-	-	-	-	-	-
Rubus hillii	1.62	-	-	-	-	-	-	-	-	-	-
Rubus parvifolius	10.56	-	-	-	-	-	-	-	-	-	-
Rubus rosifolius	2.82	-	-	-	-	-	-	-	-	-	-
Rubiaceae											
Asperula conferta	1.65	-	-	-	-	-	-	-	-	-	-
Asperula gunnii	1.10	-	-	-	-	-	-	-	-	-	-

Appendix 1 cont.	**Freq. (%)**	**1**	**2**	**3**	**4**	**5**	**5X**	**6**	**7**	**8**	**9**
Rubiaceae cont.											
Asperula scoparia var. *ulicina*	5.51	-	-	-	-	-	-	-	-	-	-
Coprosma hirtella	1.79	-	-	-	-	-	-	-	-	-	-
Coprosma quadrifida	18.69	-	-	-	-	-	-	-	-	-	-
Galium binifolium	2.68	-	-	-	-	-	-	-	-	-	-
Galium gaudichaudii	2.13	-	-	-	-	-	-	-	-	-	-
Galium liratum	0.24	-	-	-	-	-	-	-	-	-	-
Galium migrans	0.24	-	-	-	-	-	-	-	-	-	-
Galium propinquum	8.16	-	-	-	-	-	-	-	-	-	-
Leptostigma reptans	0.62	-	-	-	-	-	-	-	-	-	-
Morinda jasminoides	3.41	-	-	-	-	-	-	-	-	-	-
Opercularia aspera	12.22	-	-	-	-	-	-	-	-	-	-
Opercularia diphylla	0.55	-	-	-	-	+	-	-	S	-	-
Opercularia hispida	1.00	-	-	-	-	-	-	-	-	-	-
Opercularia varia	3.34	-	-	-	-	-	-	-	-	-	-
Pomax umbellata	5.57	-	-	-	-	-	-	-	-	-	-
Psychotria loniceroides	1.24	-	-	-	-	-	-	-	S	-	-
Rutaceae											
Acronychia oblongifolia	0.28	-	-	-	-	-	-	-	-	-	-
Asterolasia asteriscophora	0.03	-	-	+	-	-	-	-	-	-	-
Boronia algida	0.38	-	-	-	-	-	-	-	-	-	-
Boronia anemonifolia var. *anemonifolia*	0.21	-	-	-	-	-	-	-	-	-	-
Boronia anethifolia	0.07	-	-	-	-	+	-	-	S	-	-
Boronia deanei	0.03	-	+	-	-	-	-	-	S	+	-
Boronia ledifolia	0.10	-	-	-	-	-	-	-	LS	-	-
Boronia muelleri	0.55	-	-	-	-	-	-	-	-	-	-
Boronia nana var. *hyssopifolia*	0.14	-	-	-	-	+	-	-	-	-	-
Boronia parviflora	0.21	-	-	-	-	-	-	-	-	-	-
Boronia polygalifolia	0	-	-	-	-	+	-	-	-	-	-
Boronia rigens	0	-	-	-	-	+	-	-	S	-	-
Correa alba var. *alba*	0.10	-	-	-	-	-	-	-	-	-	-
Correa baeuerlenii	0.21	-	+	-	-	-	-	-	S	+	-
Correa lawrenciana var. *cordifolia*	1.55	-	-	-	-	-	-	-	-	-	-
Correa lawrenciana var. *latrobeana*	0	-	-	-	-	+	-	-	-	-	-
Correa lawrenciana var. *lawrenciana*	0	-	-	-	-	+	-	-	N	-	-
Correa reflexa var. *reflexa*	14.87	-	-	-	-	-	-	-	-	-	-
Correa reflexa var. *speciosa*	0	-	-	-	-	-	-	-	-	-	-
Crowea exalata	0.31	-	-	-	-	-	-	-	-	-	-
Eriostemon myoporoides subsp. *myoporoides*	0.21	-	-	-	-	+	-	-	-	-	-
Eriostemon trachyphyllus	1.14	-	-	-	-	-	-	-	-	-	-
Eriostemon virgatus	0.07	-	-	-	-	+	-	-	N	-	-
Phebalium carruthersii	0	-	-	+	-	-	-	-	S	-	-
Phebalium diosmeum	0.38	-	-	-	-	-	-	-	S	-	-
Phebalium ellipticum	0	-	-	+	-	-	-	-	-	-	-
Phebalium phylicifolium	0.17	-	-	-	-	+	-	-	-	-	-
Phebalium ralstonii	0.55	+	+	-	-	-	-	-	-	-	-
Phebalium rhytidophyllum	0	+	+	-	-	-	-	-	-	-	-
Phebalium squameum subsp. *squameum*	0.03	-	-	-	-	+	-	-	-	-	-
Phebalium squamulosum subsp. *argenteum*	0	-	-	-	-	+	-	-	-	-	-
Phebalium squamulosum subsp. *ozothamnoides*	0	-	-	-	-	+	-	-	-	-	-

Appendix 1 cont.	**Freq. (%)**	**1**	**2**	**3**	**4**	**5**	**5X**	**6**	**7**	**8**	**9**
Rutaceae cont.											
Phebalium squamulosum subsp. *squamulosum*	0.07	-	-	-	-	+	-	-	-	-	-
Philotheca salsolifolia	0	-	-	-	-	+	-	-	S	-	-
Sarcomelicope simplicifolia subsp. *simplicifolia*	0	-	-	-	-	+	-	-	S	-	-
Zieria arborescens subsp A.	0.03	-	-	-	-	+	-	-	-	-	-
Zieria cytisoides	0.14	-	-	-	-	-	-	-	-	-	-
Zieria fraseri subsp. B (*compacta* ms)	0	-	-	-	-	+	-	-	S	-	-
Zieria pilosa	0	-	-	-	-	+	-	-	S	+	-
Zieria smithii subsp. A	2.17	-	-	-	-	-	-	-	-	-	-
Zieria sp. D (*citriodora* ms)	0	-	+	-	-	-	-	-	N	+	-
Zieria sp. G (*buxijugum* ms)	0	+	+	-	-	-	-	-	-	-	-
Zieria sp. H (*formosa* ms)	0.03	+	+	-	-	-	-	-	-	-	-
Zieria sp. I (*parrisiae* ms)	0	+	+	-	-	-	-	-	-	-	-
Zieria sp. O (*littoralis* ms)	0.24	-	-	+	-	-	-	-	N	+	-
Sambucaceae											
Sambucus australasica	0.69	-	-	-	-	-	-	-	-	-	-
Sambucus gaudichaudiana	0.62	-	-	-	-	-	-	-	-	-	-
Santalaceae											
Choretrum candollei	0.96	-	-	-	-	-	-	-	S	-	-
Choretrum pauciflorum	0.76	-	-	-	-	-	-	-	-	-	-
Exocarpos cupressiformis	3.96	-	-	-	-	-	-	-	-	-	-
Exocarpos strictus	14.28	-	-	-	-	-	-	-	-	-	-
Leptomeria acida	0.76	-	-	-	-	-	-	-	-	-	-
Leptomeria drupacea	0.03	-	-	-	-	-	-	-	-	-	-
Omphacomeria acerba	0.58	-	-	-	-	-	-	-	-	-	-
Santalum obtusifolium	0.38	-	-	-	-	+	-	-	-	-	-
Thesium australe	0	-	+	-	-	-	-	+	-	-	-
Sapindaceae											
Alectryon subcinereus	0.65	-	-	-	-	-	-	-	-	-	-
Dodonaea multijuga	0	-	-	-	-	+	-	-	S	+	-
Dodonaea procumbens	0	-	+	-	-	-	-	-	-	+	-
Dodonaea rhombifolia	0.03	-	-	+	-	-	-	-	-	-	-
Dodonaea triangularis	0	-	-	-	-	+	-	-	S	+	-
Dodonaea triquetra	3.06	-	-	-	-	-	-	-	-	-	-
Dodonaea truncatiales	0.34	-	-	-	-	-	-	-	-	-	-
Dodonaea viscosa subsp. *angustifolia*	1.45	-	-	-	-	-	-	-	-	-	-
Dodonaea viscosa subsp. *spatulata*	0.21	-	-	-	-	-	-	-	-	-	-
Scrophulariaceae											
Derwentia derwentiana subsp. *derwentiana*	0.48	-	-	-	-	-	-	-	-	-	-
Derwentia perfoliata	0.72	-	-	-	-	-	-	-	-	-	-
Euphrasia collina subsp. *collina*	0.07	-	-	-	-	+	-	-	N	-	-
Glossostigma elatinoides	0.03	-	-	-	-	+	-	-	-	-	-
Gratiola pedunculata	0.03	-	-	-	-	-	-	-	-	-	-
Gratiola peruviana	1.58	-	-	-	-	-	-	-	-	-	-
Limosella australis	0	-	-	-	-	+	-	-	-	-	-
Mazus pumilio	0.10	-	-	-	-	+	-	-	-	-	-
Mimulus repens	0.03	-	-	-	-	+	-	-	-	-	-
Veronica calycina	14.90	-	-	-	-	-	-	-	-	-	-
Veronica gracilis	0.41	-	-	-	-	-	-	-	-	-	-

Appendix 1 cont.	**Freq. (%)**	**1**	**2**	**3**	**4**	**5**	**5X**	**6**	**7**	**8**	**9**
Scrophulariaceae cont.											
Veronica notabilis	1.89	-	-	-	-	-	-	-	-	-	-
Veronica plebeia	3.68	-	-	-	-	-	-	-	-	-	-
Veronica subtilis	0	-	-	-	-	+	-	-	-	-	-
Solanaceae											
Solanum americanum	0.72	-	-	-	-	-	-	-	-	-	-
Solanum aviculare	0.10	-	-	-	-	-	-	-	-	-	-
Solanum brownii	0.14	-	-	-	-	+	-	-	-	-	-
Solanum cinereum	0.03	-	-	-	-	+	-	-	-	-	-
Solanum linearifolium	0	-	-	-	-	+	-	-	-	-	-
Solanum prinophyllum	2.82	-	-	-	-	-	-	-	-	-	-
Solanum pungetium	4.75	-	-	-	-	-	-	-	-	-	-
Solanum stelligerum	0.10	-	-	-	-	+	-	-	S	-	-
Solanum vescum	0.34	-	-	-	-	-	-	-	-	-	-
Stackhousiaceae											
Stackhousia monogyna	2.82	-	-	-	-	-	-	-	-	-	-
Stackhousia spathulata	0.03	-	-	-	-	+	-	-	-	-	-
Stackhousia viminea	0.58	-	-	-	-	-	-	-	-	-	-
Sterculiaceae											
Brachychiton populneus subsp. *populneus*	1.41	-	-	-	-	-	-	-	-	-	-
Commersonia fraseri	1.10	-	-	-	-	-	-	-	-	-	-
Lasiopetalum ferrugineum var. *cordatum*	0.10	-	-	-	-	-	-	-	S	-	-
Lasiopetalum ferrugineum var. *ferrugineum*	0.34	-	-	-	-	-	-	-	-	-	-
Lasiopetalum macrophyllum	0.48	-	-	-	-	-	-	-	-	-	-
Lasiopetalum parvifolium	0	-	-	+	-	-	-	-	S	-	-
Rulingia dasyphylla	0.03	-	-	-	-	+	-	-	-	-	-
Rulingia hermannifolia	0	-	-	+	-	-	-	-	S	+	-
Stylidiaceae											
Stylidium graminifolium	12.39	-	-	-	-	-	-	-	-	-	-
Symplocaceae											
Symplocos thwaitesii	0	-	-	-	-	+	-	-	LS	-	-
Thymelaeaceae											
Pimelea axiflora subsp. *axiflora*	9.57	-	-	-	-	-	-	-	-	-	-
Pimelea curviflora var. *acuta*	0	-	-	-	-	+	-	-	S	-	-
Pimelea curviflora var. *gracilis*	0	-	-	-	-	+	-	+	-	-	-
Pimelea curviflora var. *sericea*	0.31	-	-	-	-	-	-	+	-	-	-
Pimelea glauca	0.03	-	-	-	-	+	-	-	-	-	-
Pimelea humilis	0.07	-	-	-	-	+	-	-	-	+	-
Pimelea ligustrina subsp. *ligustrina*	2.10	-	-	-	-	-	-	-	-	-	-
Pimelea linifolia subsp. *caesia*	0	-	-	-	-	+	-	-	-	-	-
Pimelea linifolia subsp. *collina*	0.17	-	-	-	-	-	-	-	S	-	-
Pimelea linifolia subsp. *linifolia*	3.79	-	-	-	-	-	-	-	-	-	-
Wikstroemia indica	0	-	-	-	-	+	-	-	S	+	-
Tremandraceae											
Tetratheca bauerifolia	1.24	-	-	-	-	-	-	-	-	-	-
Tetratheca labillardierei	0.10	-	-	-	-	-	-	-	-	-	-
Tetratheca pilosa subsp. *latifolia*	2.20	-	-	-	-	-	-	-	-	-	-
Tetratheca subaphylla	0.21	-	-	+	-	-	-	-	-	-	-
Tetratheca thymifolia	6.85	-	-	-	-	-	-	-	S	-	-
Ulmaceae											
Trema aspera	0.58	-	-	-	-	-	-	-	-	-	-

Appendix 1 cont.	**Freq. (%)**	**1**	**2**	**3**	**4**	**5**	**5X**	**6**	**7**	**8**	**9**
Urticaceae											
Australina pusilla	1.27	-	-	-	-	-	-	-	-	-	-
Dendrocnide excelsa	0.14	-	-	-	-	-	-	-	S	-	-
Parietaria debilis	0.21	-	-	-	-	-	-	-	-	-	-
Urtica incisa	4.85	-	-	-	-	-	-	-	-	-	-
Violaceae											
Hybanthus monopetalus	0.10	-	-	-	-	+	-	-	-	-	-
Hybanthus vernonii subsp. *vernonii*	0.07	-	-	-	-	+	-	-	-	-	-
Hymenanthera dentatum	4.85	-	-	-	-	-	-	-	-	-	-
Viola betonicifolia	5.57	-	-	-	-	-	-	-	-	-	-
Viola caleyana	0.03	-	-	-	-	+	-	-	-	-	-
Viola cleistogamoides	0	-	+	-	-	+	-	-	N	-	-
Viola hederacea	38.23	-	-	-	-	-	-	-	-	-	-
Viola sieberiana	0.10	-	-	-	-	-	-	-	-	-	-
Viscaceae											
Korthalsella rubra subsp. *rubra*	0	-	-	-	-	+	-	-	-	-	-
Notothixos subaureus	0.03	-	-	-	-	+	-	-	-	-	-
Vitaceae											
Cissus antarctica	0.03	-	-	-	-	+	-	-	S	-	-
Cissus hypoglauca	3.99	-	-	-	-	-	-	-	-	-	-
Winteraceae											
Tasmannia lanceolata	3.10	-	-	-	-	-	-	-	-	-	-

Appendix 2: Unconfirmed vascular plant taxa in or near the Eden region.

FILICOPSIDA	
Blechnaceae	
Blechnum chambersii	Unconfirmed record in Eden region
Dennstaedtiaceae	
Hypolepis amaurorachis	Unconfirmed record in Eden region
Marsileaceae	
Marsilea drummondii	Confirmed record nearby Eden region
LYCOPSIDA	
Lycopodiaceae	
Huperzia australiana	Unconfirmed record in Eden region
Lycopodiella serpentina	Unconfirmed record in Eden region
MAGNOLIOPSIDA (LILIIDAE)	
Convallariaceae	
Polygonatum multiflorum	Unconfirmed record in Eden region. Introduced
Cyperaceae	
Baumea arthrophylla	Unconfirmed record in Eden region
Bolboschoenus caldwellii	Confirmed record nearby Eden region
Bulbostylis barbata	Unconfirmed record in Eden region
Chorizandra sphaerocephala	Unconfirmed record in Eden region
Cyperus laevis	Unconfirmed record in Eden region
Eleocharis pusilla	Confirmed record nearby Eden region
Gahnia trifida	Unconfirmed record in Eden region
Lepidosperma canescens	Unconfirmed record in Eden region
Lipocarpha microcephala	Unconfirmed record in Eden region
Uncinia sp. aff. *flaccida*	Taxonomic status uncertain
Iridaceae	
Patersonia occidentalis	Unconfirmed record in Eden region & confirmed record nearby Eden region
Juncaceae	
Juncus brevibracteus	Unconfirmed record in Eden region
Juncus caespiticius	Unconfirmed record in Eden region
Juncus remotiflorus	Unconfirmed record in Eden region
Juncus thompsonianus	Unconfirmed record in Eden region
Lomandraceae	
Lomandra micrantha subsp. *tuberculata*	Unconfirmed record in Eden region
Orchidaceae	
Caladenia tentaculata	Unconfirmed record in Eden region
Corybas pruinosus	Unconfirmed record in Eden region
Diuris brevissima	Unconfirmed record in Eden region
Diuris semilunulata	Confirmed record nearby Eden region
Prasophyllum frenchii	Unconfirmed record in Eden region
Prasophyllum gracile	Taxonomic status uncertain
Prasophyllum odoratum s. lat.	Taxonomic status uncertain & unconfirmed record in Eden region
Prasophyllum rogersii	Unconfirmed record in Eden region
Prasophyllum rostratum	Unconfirmed record in Eden region
Prasophyllum striatum	Unconfirmed record in Eden region
Pterostylis acuminata	Unconfirmed record in Eden region
Pterostylis aestiva	Unconfirmed record in Eden region
Pterostylis coccina	Unconfirmed record in Eden region
Pterostylis grandiflora	Unconfirmed record in Eden region

Orchidaceae cont.	
Pterostylis longipetala	Unconfirmed record in Eden region
Pterostylis sp. aff. *rufa*	Unconfirmed record in Eden region
Thelymitra aristata	Unconfirmed record in Eden region & confirmed record nearby Eden region
Thelymitra chasmogama	Unconfirmed record in Eden region & taxonomic status uncertain
Poaceae	
Austrostipa ?nitida	Unconfirmed record in Eden region
Notodanthonia linkii var. *linkii*	Confirmed record nearby Eden region
Notodanthonia nudiflora	Unconfirmed record in Eden region
Notodanthonia procera	Unconfirmed record in Eden region
Deyeuxia rodwayi	Unconfirmed record in Eden region
Deyeuxia sp. D (aff. *parviseta*)	Unconfirmed record in Eden region
Eragrostis brownii	Unconfirmed record in Eden region
Hierochloe redolens	Confirmed record nearby Eden region
Paspalidium criniforme	Unconfirmed record in Eden region
Paspalidium radiatum	Unconfirmed record in Eden region
Poa petrophila	Unconfirmed record in Eden region
Puccinellia stricta	Confirmed record nearby Eden region
Polygonaceae	
Muehlenbeckia axillaris	Confirmed record nearby Eden region
Restionaceae	
Lepidobolis drapetioides	Unconfirmed record in Eden region
Leptocarpus brownii	Unconfirmed record in Eden region
MAGNOLIOPSIDA (MAGNOLIIDAE)	
Aizoaceae	
Tetragonia implexicoma	Confirmed record nearby Eden region
Apiaceae	
Hydrocotyle hirta	Taxonomic status uncertain
Hydrocotyle pterocarpa	Taxonomic status uncertain
Hydrocotyle rivularis	Taxonomic status uncertain
Hydrocotyle sibthorpoides	Taxonomic status uncertain
Trachymene incisa subsp. *incisa*	Unconfirmed record in Eden region
Trachymene procumbens	Unconfirmed record in Eden region
Araliaceae	
Astrotricha sp. B	Taxonomic status uncertain
Asteraceae	
Centipeda cunninghamii	Confirmed record nearby Eden region
Craspedia coolaminica	Confirmed record nearby Eden region
Gnaphalium spicatum	Taxonomic status uncertain
Leptorhynchos linearis	Taxonomic status uncertain
Picris burbidgei	Confirmed record nearby Eden region
Podolepis robusta	Unconfirmed record in Eden region
Senecio gunnii	Unconfirmed record in Eden region
Senecio lautus subsp. *lautus*	Uncertain identification
Senecio vagus	Unconfirmed record in Eden region
Solenogyne bellioides	Unconfirmed record in Eden region
Brassicaceae	
Cardamine tenuifolia	Confirmed record nearby Eden region
Campanulaceae	
Wahlenbergia gracilenta	Unconfirmed record in Eden region

Caryophyllaceae	
Spergularia augustifolia	Taxonomic status uncertain
Stellaria filiformis	Unconfirmed record in Eden region
Chenopodiaceae	
Sarcocornia blackiana	Unconfirmed record in Eden region
Scleranthus singuliflorus	Unconfirmed record in Eden region
Dilleniaceae	
Hibbertia monogyna	Unconfirmed record in Eden region
Hibbertia scandens	Unconfirmed record in Eden region
Elaeocarpaceae	
Elaeocarpus kirtonii	Unconfirmed record in Eden region
Epacridaceae	
Epacris calvertiana var. *calvertiana*	Confirmed record nearby Eden region
Fabaceae (Faboideae)	
Daviesia genistifolia	Unconfirmed record in Eden region
Daviesia squarrosa	Unconfirmed record in Eden region
Dillwynia floribunda var. *floribunda*	Unconfirmed record in Eden region
Dillwynia retorta species complex	Unconfirmed record in Eden region
Phyllota phylicoides	Unconfirmed record in Eden region
Pultenaea amoena	Taxonomic status uncertain
Pultenaea ferruginea var. *ferruginea*	Unconfirmed record in Eden region
Pultenaea flexilis	Unconfirmed record in Eden region
Pultenaea planifolia	Taxonomic status uncertain
Pultenaea procumbens	Confirmed record nearby Eden region
Swainsona galegifolia	Confirmed record nearby Eden region
Swainsona monticola	Confirmed record nearby Eden region
Fabaceae (Mimosoideae)	
Acacia buxifolia subsp. *buxifolia*	Confirmed record nearby Eden region
Gentianaceae	
Gentiana baeuerlenii	Confirmed record nearby Eden region
Geraniaceae	
Geranium obtusisepalum	Unconfirmed record in Eden region
Geraniaceae	
Geranium potentilloides var. *abditum*	Confirmed record nearby Eden region
Goodeniaceae	
Brunonia australis	Unconfirmed record in Eden region
Haloragaceae	
Myriophyllum verrucosum	Confirmed record nearby Eden region
Lamiaceae	
Prostanthera porcata	Confirmed record nearby Eden region
Loganiaceae	
Mitrasacme paludosa	Possible misidentification
Loranthaceae	
Muellerina celastroides	Unconfirmed record in Eden region
Myoporaceae	
Myoporum floribundum	Unconfirmed record in Eden region
Myrtaceae	
Callistemon salignus	Unconfirmed record in Eden region
Eucalyptus delegatensis	Confirmed record nearby Eden region
Eucalyptus dixsonii	Taxonomic status uncertain
Eucalyptus permixta	Taxonomic status uncertain

Myrtaceae cont.	
Eucalyptus bosistoana × *poylanthemos* subsp. *vestita* hybrid OR *E. poyanthemos* subsp. *longior*	Possible misidentification
Eucalyptus rossii	Confirmed record nearby Eden region
Kunzea capitata	Possible misidentification
Leptospermum glabrescens	Unconfirmed record in Eden region
Leptospermum parvifolium	Possible misidentification
Leptospermum squarrosum	Uncertain identification
Onagraceae	
Epilobium hirtigerum	Unconfirmed record in Eden region
Pittosporaceae	
Rhytidosporum inconspicuum	Taxonomic status uncertain
Polygonaceae	
Persicaria strigosa	Unconfirmed record in Eden region
Proteaceae	
Hakea salicifolia	Unconfirmed record in Eden region
Persoonia mollis subsp. *caleyi*	Confirmed record nearby Eden region
Symphionema palustris	Taxonomic status uncertain
Rhamnaceae	
Cryptandra spinescens	Unconfirmed record in Eden region
Pomaderris aurea	Unconfirmed record in Eden region
Pomaderris velutina	Unconfirmed record in Eden region
Rubiaceae	
Galium australe	Unconfirmed record in Eden region
Galium ciliare	Unconfirmed record in Eden region
Nertera granadensis	Unconfirmed record in Eden region
Rutaceae	
Eriostemon australasius subsp. *australasius*	Unconfirmed record in Eden region
Scrophulariaceae	
Gratiola pubescens	Unconfirmed record in Eden region
Solanaceae	
Solanum laciniatum	Unconfirmed record in Eden region
Solanum triflorum	Confirmed record nearby Eden region
Stackhousiaceae	
Stackhousia nuda	Unconfirmed record in Eden region
Sterculiaceae	
Rulingia rugosa	Unconfirmed record in Eden region
Tremandraceae	
Tetratheca ericifolia	Unconfirmed record in Eden region
Urticaceae	
Australina muelleri	Taxonomic status uncertain
Rostranthus suaveolens	Taxonomic status uncertain

Appendix 3: Introduced vascular plant taxa of the Eden region. Frequency is the percentage of 2906 floristic samples in which respective taxa were recorded. + indicates herbarium specimen held at NSW, ANBG or MEL.

	Frequency (%)	Herbarium specimen
CONIFEROPSIDA		
Pinaceae		
Pinus nigra var. *maritima*	0	
Pinus pinaster	0	
Pinus radiata	0.34	
MAGNOLIOPSIDA (LILIIDAE)		
Agavaceae		
Agave americana	0	
Alismataceae		
Sagittaria graminea	0	+
Alliaceae		
Agapanthus africanus	0	
Alstroemeriaceae		
Alstroemeria pulchella	0.03	
Araceae		
Zantedeschia aethiopica	0	
Asparagaceae		
Asparagus officinalis	0	
Myrsiphyllum asparagoides	0.10	+
Protoaparagus aethiopicus	0	
Commelinaceae		
Tradescantia albiflora	0.34	
Cyperaceae		
Cyperus congestus	0.10	+
Cyperus eragrostis	0.03	+
Eleocharis minuta	0	
Isolepis marginata	0.03	+
Isolepis prolifera	0.03	+
Isolepis sepulcralis	0	
Iridaceae		
Crocosmia × crocosmiiflora	0	
Gladiolus gueinzii	0.03	
Romulea rosea var australis	0	+
Sisyrinchium iridifolium	0	
Sisyrinchium sp. A	0	
Tritonia lineata	0	+
Watsonia meriana	0.03	
Juncaceae		
Juncus acutiflorus	0	+
Juncus articulatus	0.10	+
Juncus bufonius	0.07	+
Juncus bulbosus	0.03	+
Juncus cognatus	0	+
Juncus flavidus	0	+
Juncus microcephalus	0	+

Appendix 3 cont.	**Frequency (%)**	**Herbarium specimen**
Liliaceae		
Lilium formosanum	0	
Poaceae		
Agrostis capillaris	0	
Agrostis stolonifera	0	+
Aira caryophyllea	0.31	+
Aira elegans	0	
Aira elegantissima	0.10	
Aira praecox	0	
Ammophila arenaria	0.55	+
Andropogon virginicus	0	
Anthoxanthum odoratum	0.03	+
Avena fatua	0	
Axonopis affinis	0	
Briza maxima	0.17	
Briza minor	0.10	
Bromus catharticus	0.07	+
Bromus diandrus	0	
Bromus hordeaceus	0.14	+
Bromus tectorum	0	+
Cenchrus longispinus	0	+
Chloris gayana	0.03	+
Cortaderia selloana	0	
Cynodon dactylon	0.48	+
Cynosurus cristatus	0	+
Cynosurus echinatus	0	
Dactylis glomerata	0.17	+
Digitaria sanguinalis	0	
Digitaria velutina	0.03	+
Echinochloa crus-galli	0	
Ehrharta calycina	0	+
Ehrharta erecta	0	+
Ehrharta longiflora	0	
Eleusine indica	0	
Eleusine tristachya	0	
Festuca elatior	0	+
Festuca nigrescens	0	+
Festuca pratensis	0	+
Festuca rubra subsp. *rubra*	0	+
Glyceria declinata	0	+
Holcus lanatus	0.86	+
Hordeum glaucum	0	+
Hordeum marinum	0	+
Lagurus ovatus	0.03	
Lolium perenne	0.21	
Nassella neesiana	0.03	
Nassella trichotoma	0	+
Panicum capillare var. *capillare*	0	
Panicum gilvum	0	
Paspalum dilatatum	1.07	
Paspalum urvillei	0.03	
Pennisetum clandestinum	0.58	+
Pennisetum villosum	0	

Appendix 3 cont.	**Frequency (%)**	**Herbarium specimen**
Poaceae cont.		
Pentaschistis airoides	0	+
Phalaris aquatica	0.07	
Phalaris paradoxa	0	
Phleum pratense	0	+
Phyllostachys aurea	0	
Poa annua	0.07	+
Poa bulbosa	0	+
Poa pratensis	0.07	+
Polypogon monspeliensis	0.03	
Rostraria cristata	0.45	
Sclerochloa dura	0	+
Setaria gracilis	0.31	
Sporobolus indicus var. *capensis*	0.93	+
Stenotaphrum secundatum	0.17	
Vulpia bromoides	0.03	+
Vulpia megalura	0	
Vulpia myuros	0.07	
MAGNOLIOPSIDA/MAGNOLIIDAE		
Aceraceae		
Acer negundo	0	
Aizoaceae		
Aptenia cordifolia	0	+
Carpobrotus aequilaterus	0.03	
Carpobrotus edulis	0.03	
Tetragonia nigrescens	0.07	
Amaranthaceae		
Alternanthera pungens	0	
Amygdalaceae		
Prunus cerasifera	0.03	
Prunus laurocerasus	0	
Prunus persica	0	
Anacardiaceae		
Schinus molle var. *areira*	0.03	
Apiaceae		
Berula erecta	0	
Ciclospermum leptophyllum	0	
Conium maculatum	0.14	+
Daucus carota	0	
Foeniculum vulgare	0	
Hydrocotyle bonariensis	0	
Apocynaceae		
Vinca major	0.14	
Araliaceae		
Hedera helix	0	
Asclepiadaceae		
Araujia sericiflora	0.17	+
Gomphocarpus fruiticosus	0	
Tweedia coerulea	0.03	

Appendix 3 cont.	**Frequency (%)**	**Herbarium specimen**
Asteraceae		
Ageratina adenophora	0	
Arctotheca calendula	0	
Arctotheca populifolia	0.28	
Artemisia verlotiorum	0	+
Aster subulatus	0.34	
Bidens pilosa	0.48	+
Bidens tripartita	0	
Carduus pycnocephalus	0	
Carduus tenuiflorus	0	
Chrysanthemoides monilifera subsp. *rotundata*	0.03	
Cichorium intybus	0	+
Cirsium vulgare	5.78	+
Conyza albida	4.58	
Conyza bonariensis	0.21	+
Conyza canadensis var. *canadensis*	0	+
Cotula coronopifolia	0.24	+
Crassocephalum crepidioides	0	
Crepis capillaris	0.03	
Delairea odorata	0.10	+
Dimorphotheca pluvialis	0.03	
Dittrichia graveolens	0	+
Facelis retusa	0.07	
Galinsoga parviflora	0	
Gazania rigens	0	
Gnaphalium americanum	0.07	
Gnaphalium calviceps	0.07	
Gnaphalium coarctatum	0.38	+
Gnaphalium pensylvanicum	0	
Helminthotheca echioides	0	+
Hypochoeris glabra	0.28	
Hypochoeris radicata	20.82	+
Lactuca serriola	0	
Leontodon taraxacoides subsp. *taraxacoides*	0	
Onopordum acanthium subsp. *acanthium*	0	
Roldana petasitis	0	
Senecio elegans	0	
Senecio jacobaea	0	
Senecio madagascariensis	0.24	
Senecio vulgaris	0.03	
Silybum marianum	0.03	
Sonchus asper subsp. *glaucescens*	0	+
Sonchus oleraceus	2.41	
Tagetes minuta	0.14	+
Taraxicum officinale	0.03	+
Tolpis umbellata	0.14	
Vellereophyton dealbatum	0	+
Basellaceae		
Anredera cordifolia	0	
Boraginaceae		
Echium plantagineum	0	
Echium vulgare	0.03	+
Myosotis caespitosa	0	+
Myosotis discolor	0	+

Appendix 3 cont.	**Frequency (%)**	**Herbarium specimen**
Brassicaceae		
Cakile edentula	1.41	
Cakile maritima	0	+
Capsella bursa-pastoris	0	
Erophila verna	0.03	
Hirschfeldia incana	0.07	
Lepidium africanum	0.10	
Lepidium virginicum	0.14	
Rorippa nasturtium-aquaticum	0	+
Rorippa palustris	0	+
Sisymbrium officinale	0	
Sisymbrium orientale	0	
Buddlejaceae		
Buddleja davidii	0	
Cactaceae		
Opuntia aurantiaca	0	
Opuntia stricta	0	
Callitrichaceae		
Callitriche stagnalis	0.07	
Cannabaceae		
Cannabis sativa	0.03	
Caprifoliaceae		
Lonicera japonica	0.07	
Caryophyllaceae		
Arenaria leptoclados	0	+
Cerastium fontanum subsp. *vulgare*	0	
Cerastium glomeratum	1.00	+
Moenchia erecta	0.03	
Paronychia brasiliana	0.31	
Petrorhagia nanteulii	0.03	
Polycarpon tetraphyllum	0.45	
Sagina apetala	0	+
Sagina procumbens	0	
Saponaria officinalis	0	
Silene gallica	0.55	+
Spergula arvensis	0	
Spergularia marina	0	
Spergularia rubra	0.03	
Stellaria media	0.28	
Chenopodiaceae		
Atriplex patula	0	+
Atriplex prostrata	0.03	+
Chenopodium album	0	
Chenopodium ambrosioides	0	
Chenopodium detestans	0	+
Chenopodium murale	0	+
Chenopodium vulvaria	0	+
Clusiaceae		
Hypericum perforatum	0.03	

Appendix 3 cont.	**Frequency (%)**	**Herbarium specimen**
Crassulaceae		
Crassula multicava	0	+
Convolvulaceae		
Convolvulus arvensis	0	+
Cuscuta campestris	0	+
Ericaceae		
Erica lusitanica	0	
Euphorbiaceae		
Euphorbia helioscopia	0	+
Euphorbia lathyrus	0.03	+
Euphorbia paralius	0	+
Euphorbia peplus	0.21	+
Fabaceae (Caesalpinioideae)		
Gleditsia triacanthos	0	+
Senna pendula var. glabrata	0	+
Senna septemtrionalis	0	+
Senna × floribunda	0	+
Fabaceae (Faboideae)		
Astragalus hamosus	0	+
Coronilla varia	0.07	
Cytisus scoparius	0	+
Dipogon lignosus	0	+
Genista linifolia	0	
Genista monspessulana	0	
Lotus corniculatus	0.03	+
Lotus suaveolens	0	+
Lotus uliginosus	0	+
Medicago arabica	0	
Psoralea pinnata	0	+
Robinia pseudoacacia	0	+
Trifolium arvense	0.21	
Trifolium campestre	0.14	
Trifolium dubium	0.45	+
Trifolium fragiferum	0	+
Trifolium glomeratum	0.03	
Trifolium pratense	0.03	
Trifolium repens	1.07	+
Trifolium striatum	0.03	
Trifolium subterraneum	0.03	
Ulex europaeus	0	
Vicia hirsuta	0	
Vicia sativa subsp. *angustifolia*	0	+
Vicia tetrasperma	0.03	
Vicia villosa	0	
Fabaceae (Mimosoideae)		
Acacia baileyana	0.03	
Acacia baileyana × decurrens	0	+
Acacia decurrens	0	+
Acacia podalyriifolia	0	
Acacia pravissima	0	+
Acacia saligna	0	
Acacia vestita	0	
Paraserianthes lophantha subsp. *lophantha*	0	+

Appendix 3 cont.	**Frequency (%)**	**Herbarium specimen**
Fumariaceae		
Fumaria bastardii	0	
Fumaria officinalis	0.03	
Gentianaceae		
Centaurium erythraea	3.82	+
Centaurium pulchella	0	+
Centaurium tenuiflorum	0.03	+
Geraniaceae		
Erodium cicutarium	0	
Geranium molle subsp. *molle*	0	
Hydrangeaceae		
Hydrangea macrophylla	0	
Lamiaceae		
Leonotis leonurus	0	+
Mentha pulegium	0.07	
Mentha × piperita	0	+
Mentha × spicata	0	+
Mentha × piperita nothomorph *citrata*	0	
Prunella vulgaris	1.93	+
Salvia verbenaca	0.03	
Stachys arvensis	0	+
Linaceae		
Linum trigynum	0	
Lythraceae		
Cuphea aff. *hyssopifolia*	0	+
Malaceae		
Cotoneaster franchetii	0.07	
Cotoneaster glaucophyllus	0	
Cotoneaster microphyllus	0	+
Crataegus monogyna subsp. *nordica*	0.24	
Malus × domestica	0	
Pyracantha angustifolia	0	
Malvaceae		
Lagunaria patersonii	0	
Malva parviflora	0	
Modiola caroliniana	0.34	
Sida rhombifolia	0.24	
Meliaceae		
Melia azedarach	0	
Moraceae		
Maclura pomifera	0	
Myrtaceae		
Leptospermum laevigatum	0.72	
Oleaceae		
Ligustrum sinense	0.10	
Ligustrum vulgare	0.03	
Olea europaea subsp africana	0	
Onagraceae		
Oenothera affinis	0	
Oenothera stricta subsp. *stricta*	0	

Oxalidaceae		
Oxalis corniculatus	0	
Oxalis pes-caprae	0	
Oxalis purpurea	0	+
Oxalis articulata	0	
Oxalis incarnata	0.03	
Papaveraceae		
Argemone ochroleuca subsp. *ochroleuca*	0	
Eschscholzia californica	0	
Papaver hybridum	0	+
Papaver somniferum subsp. *somniferum*	0	+
Passifloraceae		
Passiflora edulis	0.03	
Phytolacaceae		
Phytolacca octandra	0.48	
Pittosporaceae		
Sollya heterophylla	0	
Plantaginaceae		
Plantago coronopus	0	
Plantago lanceolata	2.27	+
Plantago major	0.10	
Polygalaceae		
Polygala myrtifolia	0	
Polygonaceae		
Acetosa sagittata	0.07	+
Acetosella vulgaris	0.48	+
Fallopia japonica	0	+
Persicaria maculosa	0.03	+
Polygonum aviculare	0.03	
Rumex conglomeratus	0	
Rumex crispus	0.10	
Primulaceae		
Anagallis arvensis	2.37	+
Ranunculaceae		
Batrachium trichophyllum	0	+
Ranunculus repens	0	
Ranunculus scleratus	0	+
Rosaceae		
Potentilla recta	0	+
Rosa rubiginosa	0.72	+
Rubus fruticosus	0.14	
Rubus laciniatus	0	+
Rubus ulmifolius	2.89	
Rubus vestitus	0	+
Rubiaceae		
Coprosma repens	0.03	
Galium aparine	0	
Galium tricornatum	0	
Sherardia arvensis	0.03	
Salicaceae		
Populus alba	0	
Populus nigra	0	
Salix alba	0.14	+

Salicaceae cont.		
Salix alba var vittelina	0	
Salix babylonica	0	
Salix cinerea	0	+
Salix fragilis	0	
Salix matsudana × alba	0	
Salix viminalis	0	+
Salix × calodendron	0	+
Salix × reichardtii	0	+
Salix × rubens	0	
Sambucaceae		
Sambucus nigra	0	
Scrophulariaceae		
Linaria arvensis	0	+
Mimulus moschatus	0	+
Orobanche minor	0	
Verbascum blattaria	0	+
Verbascum thapsus subsp. *thapsus*	0	+
Verbascum virgatum	0.21	+
Veronica anagallis-aquatica	0	+
Veronica catenata	0	+
Veronica persica	0.07	
Veronica serpyllifolia	0	
Simaroubaceae		
Ailanthus altissima	0.03	+
Solanaceae		
Cestrum parqui	0	+
Datura stramonium	0	+
Lycium barbarum	0	
Lycium ferocissimum	0.03	
Nicandra physalodes	0	
Physalis ixocarpa	0	+
Physalis peruviana	0.21	+
Solanum chenopodioides	0.34	+
Solanum mauritianum	0	
Solanum nigrum	1.24	+
Solanum pseudocapsicum	0.48	+
Urticaceae		
Urtica urens	0	
Verbenaceae		
Lantana camara var. *camara*	0	+
Verbena bonariensis	1.20	
Verbena incompta	0	+
Verbena officinalis	0	+
Verbena rigida	0.41	+
Violaceae		
Viola odorata	0.03	
Zygophyllaceae		
Tribulus terrestris	0	+

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A survey of 25 remnant vegetation sites in the South Western Slopes, New South Wales

G.E. Burrows

Burrows, G.E. (Johnstone Centre, Charles Sturt University, PO Box 588, Wagga Wagga NSW Australia, 2678) 1999. A survey of 25 remnant vegetation sites in the South Western Slopes, New South Wales. Cunninghamia *6(2): 283–314.*

A presence/absence survey of 25 remnant vegetation sites, principally Nature Reserves and State Forests, was carried out in the South Western Slopes (SWS) of New South Wales. A total of 658 taxa were recorded of which 188 (29%) were exotics. Eleven sites had an overstorey dominated by *Callitris glaucophylla* or *Eucalyptus camaldulensis* and 14 sites had an overstorey dominated by various eucalypt species such as *Eucalyptus blakelyi, Eucalyptus goniocalyx, Eucalyptus macrorhyncha, Eucalyptus polyanthemos, Eucalyptus rossii* and *Eucalyptus sideroxylon.* The *Callitris glaucophylla/Eucalyptus camaldulensis* dominated sites were in the western half of the region, were flatter and at lower elevation (average minimum and maximum elevations were 191 and 214 m, respectively), were smaller (average area 646 ha), were usually grazed more intensely, had a smaller average number of species per site (151) and a larger average percentage of introduced species (40%). In contrast, the sites dominated by various eucalypt species were usually in the eastern half of the region, had greater relief and were at higher elevation (average minimum and maximum elevations were 294 and 520 m, respectively), were larger (average area 1161 ha), were usually grazed less intensively, had a larger average number of species per site (179) and a smaller average percentage of introduced species (27%). This study provides the first published set of relatively comprehensive species lists for the SWS and has provided information relevant to species distribution, proportion of introduced species in the flora, threatened species, areas of conservation significance and directions for future research.

Introduction

Mainland NSW is divided into 13 botanical regions (Harden 1990). The South Western Slopes (SWS) botanical region is probably the most intensively and extensively disturbed region of NSW. A combination of mainly flat to undulating country, relatively fertile soils and reliable rainfall led to European settlement proceeding rapidly between 1829 and 1845 (Moore 1953a) and this led to large scale modification of the landscape for cropping and grazing of domestic stock over the next 100 years. Since 1945 the widespread adoption of pasture improvement involving the use of fertilisers and potentially invasive grasses and legumes has been responsible for a continued decline in native vegetation condition and diversity. The degree of disturbance is reflected in the small percentage of the SWS conserved in the reserve system and in the small number of botanical surveys.

In the 1980s the SWS had the second lowest percentage (0.2%) of reserved land (National Parks, Nature Reserves, State Recreation Areas) in NSW (Benson 1988). In the SWS there are no National Parks, six Nature Reserves (Hattons Corner 4 ha, Narrandera 71 ha, Table Top 103 ha, The Rock 341 ha, Burrinjuck 1300 ha, Ulandra 3930 ha) and two State Recreation Areas (Burrinjuck 173 ha, Bethungra 385 ha) with a total area of 6307 ha. In 1986 the total area of reserved land in NSW was 3 438 941 ha (4.2%), while in 1997 total reserved land in NSW had increased to 4 536 513 ha (5.7%) (Roger Good, pers. comm.), but there had been no additions to the reserve system in the SWS.

An indication of the limited research into the flora of the SWS is given by the compilations of floristic lists for NSW prepared by various authors at the National Herbarium of NSW. In total, only 26 of 813 lists recorded by Pickard (1972), Bryant & Benson (1981), Keith (1988) and Benson & Melrose (1993) are relevant to the SWS and several of these lists record only a limited number of species.

Given the small proportion of the SWS in the reserve system and the limited botanical research undertaken in the region it was considered useful to construct relatively comprehensive species lists for many of the larger areas of remnant vegetation. This broad scale approach aims to present information on: i) species occurrence and distribution in the SWS, ii) presence of threatened flora, iii) species and areas of conservation significance, iv) presence of introduced species and v) physical and botanical differences between the eastern and western parts of the SWS. This information should assist in conservation planning in the region while indicating future research areas.

Previous studies

General descriptions of the vegetation of the SWS are provided by Beadle (1981), Costermans (1981), Gillison & Walker (1994) and Sheahan (1998). Detailed studies of the native vegetation of the SWS or adjoining areas are, in chronological order, as follows:

Moore (1953a) described and mapped the pre-European extent of vegetation in the south-eastern Riverina which included the current study area but also extended further to the north and to the south west. He recorded 435 species (103 exotics) in seven alliances and provided separate species lists for the alliances, ranging from 48 to 287 species per alliance. Moore (1953b) described the disclimax communities (pastures) of the same region, particularly in its western half.

McBarron (1955) recorded observations on approximately 500 native, 260 exotic and 350 cultivated species in the Albury, Holbrook and Tumbarumba districts. He concentrated on disturbed areas rather than remnant vegetation in the mountains and arranged the information taxonomically rather than by site or community groupings.

Norris and Thomas (1991) studied 19 rocky outcrops and ranges to the west of the present study area. Each site was assessed with up to three 20 × 20 m quadrats or by traverses. A total of 338 species were recorded (16% exotic) with an average of 46 species per site.

Howard (1994), in an unpublished report, provided a summary of the condition of the vegetation in 72 State Forests in the SWS and the southern half of the Central Western Slopes. A listing of the main tree, shrub and groundcover species was provided for each State Forest. Fourteen of the 25 sites assessed in the present study were covered by Howard (1994). Twelve State Forests were listed as having a high biological diversity including five assessed in the present study (Benambra, Ellerslie, Livingstone, Pulletop and Tumblong).

Prober and Thiele (1995) studied species diversity in *Eucalyptus albens* woodlands in the Central Western Slopes. By using a series of traverses they recorded 179 native species and 130 exotic species in 34 sites, all of which were less than 32 ha in area. Prober (1996) studied grassy *Eucalyptus albens* woodlands from southern Queensland to northern Victoria, although the survey work was largely restricted to NSW. Prober (1996) recorded 472 species (375 native) from 90 20 m × 50 m quadrats and noted that remnant quality declined significantly in southern NSW, indicating a need for a greater conservation effort in southern areas.

Bos and Lockwood (1996) studied the flora, fauna and recreation opportunities of 45 forest blocks in the SWS biogeographic region (see Thackway and Cresswell 1995 for borders), including 18 of the 25 sites studied in the present study. A total of 225 8 × 8 m or 20 × 20 m quadrats were surveyed (an average of five quadrats per forest block) and a total of 456 species were recorded and 16 communities recognised.

Benson et al. (1997) studied the native grasslands of the Riverine plain which is to the west of the current study area. They assessed 67 10 × 20 m quadrats and recorded 224 species (25% exotic) in six communities.

There has been a recent emphasis on the assessment of roadside vegetation in the SWS. Walker (1997b) listed c. 130 species for the roadside vegetation in Coolamon Shire, with numerous listings of 10–30 species for specific areas. Similar assessments have been carried out for the Olympic Way (Stelling 1996), Tumut Shire (Walker 1997a) and Lockhart Shire (Bull 1997).

Stelling (1998), in a revegetation guide for the SWS between the Murray and Murrumbidgee Rivers, provided approximately 75 cross sectional vegetation profiles with lists of the main tree, shrub and groundcover species.

Climate

Average annual rainfall ranges from approximately 450 mm at Matong and Brookong State Forests in the west of the study area to approximately 900 mm at Ellerslie, Murraguldrie and Tumblong State Forests in the east; an increase of 450 mm/year in 90 to 100 km (Table 1). See Moore (1953a) for a map of rainfall isohyets in the study region. February is the driest month for most of the region, while October is the wettest month for the drier and more westerly sites and the winter months are the wettest for the more easterly sites.

Table 1. Summary of meteorological data for selected weather stations in the study area (Bureau of Meteorology 1998) arranged by increasing average annual rainfall.

	highest mean maximum daily temperature (°C)	lowest mean minimum daily temperature (°C)	highest mean monthly rainfall (mm)	lowest mean monthly rainfall (mm)	average annual rainfall (mm)
Narrandera	32.2 Jan	2.5 Jul	46 Oct	31 Mar	451
Matong Forestry	32.9 Jan	2.3 Jul	51 Oct	24 Dec	462
Junee	32.4 Jan	2.3 Jul	53 Oct	36 Feb	533
Wagga Wagga	31.2 Jan	2.7 Jul	61 Oct	38 Feb	585
Cootamundra	31.5 Jan	1.9 Jul	61 Oct	39 Feb	626
Gundagai	31.6 Jan	2.1 Jul	79 Jul	41 Feb	714
Albury	30.1 Jan, Feb	2.8 Jul	102 Jul	36 Feb	785
Adelong	30.8 Jan	0.9 Jul	84 Jun	42 Feb	795
Murraguldrie	29.7 Jan	1.6 Jul	95 Aug	51 Feb	892
Carabost	28.9 Jan	0.7 Jul	112 Jul	58 Feb	1049

Methods

A total of 25 sites were surveyed in this study (Table 2, Fig. 1). Sites 1–10 were in the western half of the SWS, consisted of relatively flat country and had an overstorey dominated by *Callitris glaucophylla*. Berry Jerry and Currawananna State Forests (sites 10 and 11) differ from the other western sites as both adjoin the Murrumbidgee River and had a mix of *Callitris glaucophylla* and *Eucalyptus camaldulensis* communities. Currawananna SF was dominated by Cypress Pine and had a narrow ribbon of River Red Gum on its southern border, while Berry Jerry SF was dominated by River Red Gum and had a small area of Cypress Pine and Box eucalypts on its southern boundary. Sites 12–25 were mainly in the eastern half of the SWS and consisted mainly of rocky outcrops and the lower slopes of the Great Dividing Range, with an overstorey dominated by various eucalypt species such as *Eucalyptus blakelyi, Eucalyptus goniocalyx, Eucalyptus macrorhyncha, Eucalyptus polyanthemos, Eucalyptus rossii* and *Eucalyptus sideroxylon*. Sites 12–16, while mainly rocky outcrops, had a lower fringe of vegetation similar to the *Callitris glaucophylla* communities. A summary of attributes pertaining to the eastern and western sites is presented in Table 3.

At each site species were recorded as either present or absent (Appendix 1), there were no recordings of cover, abundance or distribution. Each site was surveyed by making a series of systematic traverses, at least three times in a year, usually starting in late winter or early September and finishing in early to mid December (Appendix 2). Each survey trip usually consisted of at least four hours in the field, usually by a pair of collectors. Additional species recordings for Matong and Lester State Forests and Ganmain and Coolamon Reserves were obtained from 60 semipermanent quadrats assessed at monthly intervals during spring 1996 for another project. All sites were on public land except for Malebo Range and Flowerpot Hill, although permission to cross private land must be obtained to access Pulletop, Ellerslie, Benambra and Tumblong State Forests and Tabletop Nature Reserve.

Table 2. Various characteristics of the 25 sites assessed (SF: State Forest, NR: Nature Reserve).

Site no.	Site name	Abb-rev'n	Area (ha)	Elev'n range (m asl)	Total species recorded	No. native species recorded	% exotics
1	Brookong SF	bro	346	150–180	114	76	33
2	Milbrulong SF	mil	376	200–225	131	91	31
3	Kockibitoo SF	koc	244	160–170	117	75	36
4	Matong SF	mat	3176	160–170	221	135	39
5	Ganmain Reserve	gan	91	195–200	152	107	30
6	Lester SF	les	790	210–250	167	104	38
7	Kindra SF	kin	520	220–240	145	99	32
8	Coolamon Reserve	coo	58	250–260	163	102	37
9	Winery Hill	wh	c. 20	230–295	129	65	50
10	Currawananna SF	cur	286	165–190	184	95	48
11	Berry Jerry SF	bj	1198	165–170	135	66	51
12	Pomingalarna Park	pom	226	200–295	165	112	32
13	Malebo Range	mal	c. 400	260–388	164	103	37
14	Galore Hill Reserve	gh	c. 500	240–380	191	140	27
15	Flowerpot Hill	fp	c. 100	290–462	117	91	22
16	The Rock NR	tr	341	210–554	213	159	25
17	Pulletop SF	pul	809	360–450	119	91	24
18	Livingstone SF	liv	2183	320–470	190	146	23
19	Tabletop NR	tt	103	360–720	153	117	24
20	Benambra SF	ben	1445	300–640	191	136	29
21	Murraguldrie SF	mur	4485	350–701	221	160	28
22	Ellerslie SF	ell	909	280–545	199	135	32
23	Tumblong SF	tum	712	270–588	186	138	26
24	Mundarlo Road	mun	c. 100	270–325	132	94	29
25	Ulandra NR	ula	3930	400–761	258	190	26

Most of the main areas of remnant forest or woodland were surveyed in the western half of the study area, but in the east large areas of forest on private property were not assessed (Fig. 1).

The data in Appendix 1 were analysed using the PATN package. PATN analysis assumes that sites are of equal area and surveyed with uniform method and intensity. This is not the case in this study but allowing for these limitations broad trends in site relationships can still be investigated. Presence–absence data from each site were used to classify sites into groups of similar composition. The hierarchical, agglomerative, flexible unweighted paired group arithmetic average (UPGMA) procedure in the PATN package (Belbin 1994) was used, with the Czekanowski dissimilarity coefficient and default value, beta = -0.1. All species were included in the analysis.

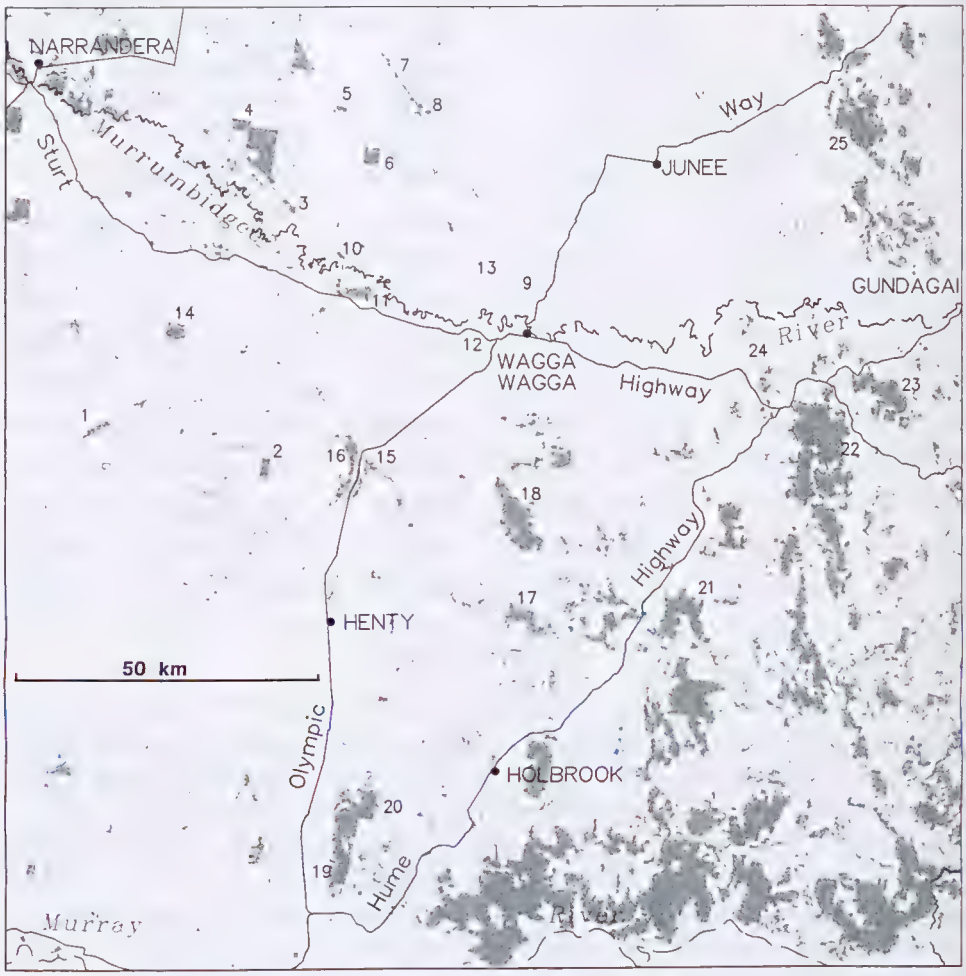

Fig. 1. Tree cover in the study area based on Department of Land and Water Conservation maps showing the approximate location of the 25 study areas. Site area numbers follow Table 2. The maps on which this figure are based were prepared during 1990–1993 from aerial photography carried out during 1985–1990. The minimum area of tree cover for inclusion was 100 ha. Note the increase in remnant tree cover to the east, especially east of the Hume Highway. Much of the south east corner of this figure is outside the SWS biogeographic region and to a lesser extent the SWS botanical region.

Results and discussion

A total of 658 taxa were identified to the level of species or subspecies and of these 188 (29%) were introduced species (Appendix 1). Other studies west of the Great Dividing Range in NSW have recorded between 16 and 25% exotics (Moore 1953a, Cunningham et al. 1981, Norris & Thomas 1991, Sivertsen & Metcalfe 1995, Benson et al. 1997). Sivertsen and Metcalfe (1995) considered 20% exotics a high proportion and on this basis all sites surveyed in the present study had a high to very high percentage of weed species (Table 2, Appendix 1).

Ninety-nine families were recorded. The six most common families or subfamilies recorded were the Poaceae (88 species, 43% exotic), Asteraceae (86 species, 31% exotic), Fabaceae-Faboideae (48 species, 35% exotic), Orchidaceae (25 species, none exotic), Cyperaceae (24 species, 8% exotic) and Fabaceae-Mimosoideae (24 species, none exotic). These five families accounted for 45% of the species recorded. The Poaceae, Asteraceae and Fabaceae-Faboideae have also been the most species abundant families in other studies in this general region (Moore 1953a, Norris & Thomas 1991, Sivertsen & Metcalfe 1995, Benson et al. 1997).

As noted the sites were divided into two main groups (western and eastern) based on location, landform and dominant overstorey species and some of the main attributes of the two groups are presented in Table 3.

Table 3. Characteristics of sites in the western and eastern parts of the study area.

Attribute	Western sites (1–11)	Eastern sites (12–25)
dominant overstorey species	*Callitris glaucophylla*, *Eucalyptus camaldulensis*	various *Eucalyptus* species
usual grazing intensity	medium to high	nil to low
average area (ha)	646	1161
average elevation range (m asl)	191–214	294–520
average no. spp./site	151	179
average no. native spp./site	92	129
range: no. native species/site	65–135	91–190
average no. of introduced species/site	58	49
average % introduced species/site	39	27

Analysis of the data in Appendix 1 by the PATN package (Fig. 2) generally supported the division of the sites into western and eastern groups. The flat *Callitris glaucophylla* dominated areas (sites 1–8) were grouped together, along with site 10 (Currawananna SF) which had less than 5% of its area covered by *Eucalyptus camaldulensis* forest/woodland. Likewise, the easterly areas without a lower fringe of *Callitris glaucophylla* type vegetation (sites 17–25) were grouped together, with the subgroupings usually based on geographical proximity. Interestingly, Ulandra NR and Livingstone SF were grouped together although they are 80 km apart. Of the five rocky outcrops with a lower fringe of *Callitris glaucophylla* type vegetation (sites 12–16) three sites (Pomingalarna Park, Malebo Range and Galore Hill Reserve) were grouped with the flatter western sites, but distinct from them, and two sites (The Rock Nature Reserve and Flowerpot Hill) were grouped with the eastern sites, but again were distinct from them. Berry Jerry SF (site 11) which had over 90% *Eucalyptus camaldulensis* cover was indicated to be distinct from all other sites.

Most species were recorded at few sites and few species were found at more than 90% of sites (Fig. 3). Sivertsen and Metcalfe (1995) noted that 41% of the species recorded during their study occurred only once or twice. They also noted while this alone does

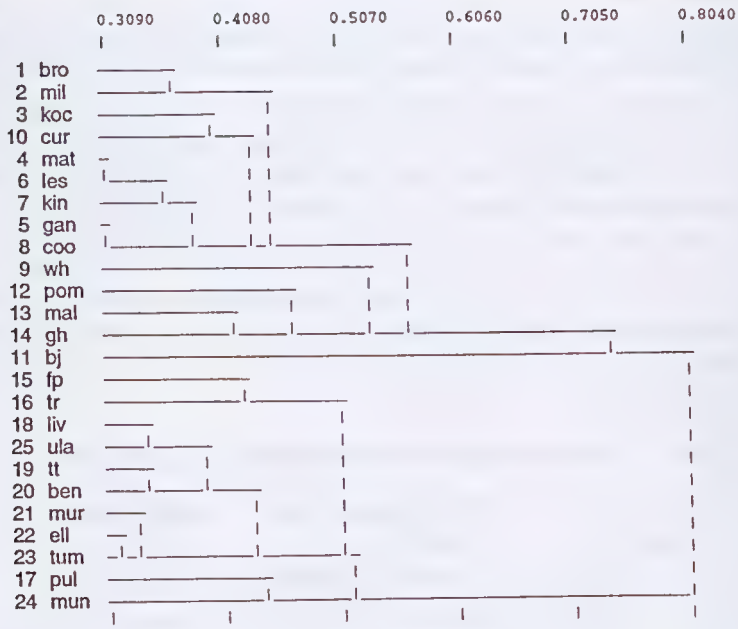

Fig. 2. Dendrogram showing the two main groups of sites and the relative isolation of site 11, Berry Jerry SF. Site name abbreviations follow Table 2.

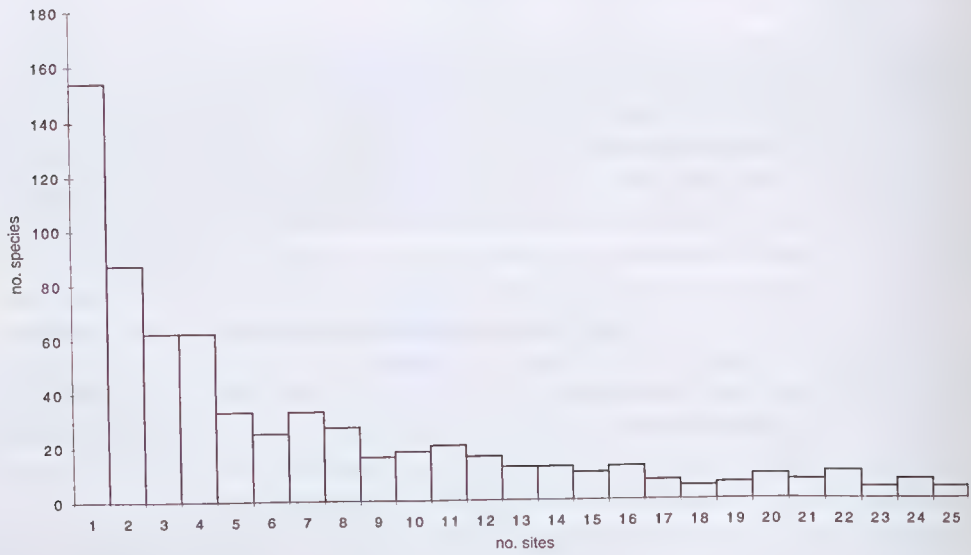

Fig. 3. Histogram indicating that a large number of taxa were recorded at only a few sites, while few taxa were found at most sites.

not confer rare or threatened status, it does indicate that further investigation of these populations is warranted. The study of Sivertsen & Metcalfe (1995) was quadrat based while the present study was based on wide ranging traverses at different times of the year. Thus most species recorded at only one site (e.g. shrub species such as *Cassinia laevis, Astroloma humifusum, Beyeria viscosa, Dampiera lanceolata, Goodenia ovata, Prostanthera ovalifolia, Zieria cytisoides* and *Cyphanthera albicans* recorded only at The Rock NR) can be reliably considered to be locally rare. In the present study 37% of taxa were recorded at only one or two sites and this finding is discussed below in relation to areas of possible conservation significance.

The fives sites with the lowest native species diversity were all in the west of the study area (Brookong, Milbrulong, Kockibitoo and Berry Jerry State Forests and Winery Hill). The five sites with greatest native species diversity were eastern-type sites and three were reserves (Galore Hill Reserve and The Rock and Ulandra Nature Reserves) and two were State Forests (Livingstone and Murraguldrie).

At November 1997, 7555 plant taxa had been recorded for NSW in the census database (National Herbarium of NSW) with 1463 taxa recorded for the SWS and of these 471 (32%) were introduced. Thus the present study recorded approximately 45% of all SWS taxa, 47% of native species and 40% of introduced species. The area of the 25 study sites was 23 354 ha which is less than 1% of the SWS. Thus a relatively large percentage of species were recorded in a relatively small area. Further survey work in the *Acacia pendula–Atriplex nummularia* alliance (Moore 1953a), the flood plains of the Murrumbidgee and Murray Rivers, swamps and clay pans, areas bordering on the Southern Tablelands and in intensively disturbed areas would result in a significant increase in the number of species recorded.

The study added numerous species to the census database (National Herbarium of NSW) of species recorded for the SWS. Of the 658 taxa recorded 107 (16%) had not been previously recorded for the SWS (Harden 1990–1993). As might be expected most of these species were recorded from a small number of sites (72 or 67% were recorded at only one or two sites), but several (eg. *Bursaria spinosa, Stachys arvensis, Pterostylis mutica, Urtica urens, Cotula australis, Goodenia hederacea* and *Anagallis arvensis*) were found at 9 or more sites. While not recorded for the SWS on the NSW Herbarium's census database many of the 107 species have been recorded for the region in other studies, eg. the seven species listed above were all recorded by McBarron (1955). Only two species were found that had not been previously recorded for NSW and one of these was *Pultenaea humilis*. This species is known from Victoria and Tasmania and was found at Murraguldrie SF, c. 50 km north of the NSW/Victorian border. Herbarium specimens of the majority of these 107 taxa have been sent to the NSW National Herbarium.

Rare or Threatened Australian Plants

In the 1995 update of *Rare or threatened Australian plants* (Briggs & Leigh 1996) 19 ROTAPs are listed for the SWS and in a 1997 update obtained from Environment Australia 21 ROTAPs were listed (Burrows 1998). Of these 21 species six are listed as

presumed extinct in the SWS and one species (*Aphanes pumila*) is known from only a single collection and is not described in the Flora of NSW. The remaining 14 species are classified as Endangered (1 species), Vulnerable (8 species), Rare (2 species) or Poorly Known (3 species) (Burrows 1998). Of these 14 species three (*Ammobium craspedioides, Senecio garlandii* and *Diuris tricolor)* were recorded during this study. The first two species are listed as 'Vulnerable' and the last as 'Poorly Known'.

Ammobium craspedioides is recorded in the *Flora of NSW* as 'rare, confined to the Yass district' (Harden 1992) but a small population was found in Livingstone State Forest (c. 30 km south of Wagga) and presumably there may be further populations in the intervening distance of over 100 km.

Senecio garlandii (Woolly Ragwort) is probably the most easily observed ROTAP in the SWS as it is a conspicuous part of the flora of the upper part of The Rock NR and is sometimes mistakenly considered a weed. Previously *Senecio garlandii* was known from only six or seven sites and only one of these, The Rock NR, was a conservation area. *Senecio garlandii* was recorded from a further three sites of which two are conservation areas (Ulandra and Table Top Nature Reserves) and this study has confirmed its apparent habitat preference for the upper scree slopes of steep sided hills and rocky outcrops in the SWS (Burrows 1995).

Diuris tricolor was recorded at several sites (sites 1, 3, 4, 6, 8 and 10) in the *Callitris glaucophylla* communities to the west of Wagga Wagga and while never abundant the 'Poorly Known' listing may not be appropriate.

Brachycome papillosa was recorded from one site in the western part of the SWS. This species is listed as Vulnerable but is not recorded for region 52, the SWS (Briggs & Leigh 1996).

Further study arising from the present investigation

Keith (1988) noted that 'Floristic lists are often the only source of botanical information for a particular area and may serve as a useful starting point for more detailed study.' Likewise this study has provided the impetus for more detailed quadrat based studies of various aspects of the remnant vegetation in the SWS. Seven of the eight areas of reserved land in the SWS are located in the eastern half of the region and the other area (Narrandera NR) is a small area of *Eucalyptus camaldulensis* forest. Thus no dryland vegetation in the western half of the SWS is included in the reserve system. Essentially the only remnant vegetation in this western area were several *Callitris glaucophylla* dominated State Forests. These forests superficially appeared to be of low conservation value as the overstorey was a *Callitris* monoculture through eucalypt ringbarking, no shrub layer was present and the ground layer was dominated by introduced species. This study showed that many of these forests had a relatively high diversity of native species (average 95 native species/site), but did not provide information on distribution or abundance. To provide this information a study funded by the National Estates Program (NEP 96 422) assessed 105 10 × 10 m quadrats in several *Callitris glaucophylla* dominated woodlands and forests (including sites 4, 5, 6 and 8 of the present study) at monthly intervals over a four month period. This study revealed

that some quadrats had a high diversity of native species per quadrat (up to 46) and indicated that some of these areas had a high conservation value (Burrows, unpublished data).

In addition, there is an urgent need for research into areas such as detailed vegetation mapping, reserve selection, off-reserve remnant vegetation management, weed management and regeneration techniques (Yates & Hobbs 1997).

Areas of possible conservation significance

This study provides information which may be useful in identifying areas that might be of conservation significance.

a) In the west of the SWS Matong SF had a much larger area than the other *Callitris glaucophylla* sites surveyed and had the highest number of total species and native species recorded, 221 and 135, respectively (Table 2). Morgan and Terrey (1992) considered that Matong SF was one of two 'key areas' for conservation within the lower slopes of the SWS, based mainly on its size. It appears that this is a valid assessment based on the results of this study and on unpublished quadrat based surveys.

b) Coolamon Reserve is the southern extension of Kindra SF. With assistance from State Forests of NSW this area is now managed by a local landcare group for its conservation value and is a de facto nature reserve. On the basis of the present results it would be beneficial if similar arrangements could be organised for Ganmain Common as this site had a high diversity of native species and relatively few exotic species were recorded.

c) Of the State Forests in the eastern half of the SWS Livingstone SF and Murraguldrie SF require further assessment as they had the highest number of native species, combined with relatively low percentages of exotic species. Howard (1994) listed Livingstone SF, along with Benambra, Ellerslie, Tumblong, Pulletop and eight other State Forests not covered in the present study, as priority areas for future evaluation due to their high biological interest. Murraguldrie SF was assessed as having only restricted biological interest by Howard (1994).

The results were also assessed for sites that possessed a large number of taxa that were recorded only once or twice during the study. It was considered that these sites may be of conservation significance given the number of locally rare species they held. Matong SF and Ganmain Common had relatively large numbers of locally rare species for sites 1–11, while The Rock NR, Ulandra NR and Murraguldrie SF had relatively large numbers of locally rare species for sites 12–25. For the non-reserve areas these results again indicate the potential conservation significance of Ganmain Common and Matong and Murraguldrie State Forests. Currawananna SF and Berry Jerry SF also had large numbers of infrequently recorded species as they had the only regularly flooded *Eucalyptus camaldulensis* communities studied.

Indicator species of eastern and western areas

While the overstorey species that defined the various sites were readily ascertained the results indicated that there were various shrub and groundlayer species that had distinct distribution patterns and were part of defining sites 1–11 and sites 12–25. Species that were recorded from at least 5 sites and up to 16 sites were useful as potential indicator species, a total of 234 species. Species that were recorded at less than five sites were too infrequent to give an accurate indication of distribution, while species recorded at more than 16 sites were usually widespread in the SWS.
Indicator species were defined as follows:

a) in the western sites:
   i) 5 to 6 recordings in sites 1–11, 0 to 5 recordings at sites 12–16, and 0 recordings for sites 17–25, or
   ii) 7 to 11 recordings in sites 1–11, 0 to 5 recordings at sites 12–16, and 0–1 recordings for sites 17–25.
b) in the eastern sites:
   i) 5 to 6 recordings in sites 12–25 and 0 recordings for sites 1–11, or
   ii) 7 to 14 recordings in sites 12–25 and 0–1 recordings for sites 1–11.

This is similar to the criteria used by Benson et al. (1997) that indicator species were those species that occurred in more than 40% of the sites in a community and were rarely or never found in another community.

Of the 234 species considered, 176 were native and 58 were introduced. Ninety-nine native species (44% reduction) and 15 introduced species (74% reduction) met the above selection criteria. Sivertsen and Metcalfe (1995) noted in their PATN analysis that exotic herbaceous species were not considered as they have a tendency to grow in a wide range of environments and native communities and this is also shown in the present study. A listing of the 20 most frequently recorded native indicator species for sites 1–11 and 12–25 is given in Table 4.

A similar analysis of the data was performed but using the site groupings indicated by the PATN analysis (Fig. 2, Table 5). The site groupings used were sites 1–14 but excluding site 11 and sites 15–25. Indicator species were defined as those having a minimum of 7 recordings in one of the site groupings and:

i) if there were 7 recordings in one group a maximum of one recording was permitted in the other group,

ii) if there were 8–11 recordings in one group a maximum of two recordings was permitted in the other group, and

iii) if there were 12–13 recordings in one group a maximum of three recordings was permitted in the other group.

In general there was a good correlation between the two approaches especially for the more westerly sites where there was a 80% correlation between the left hand side columns of Tables 4 and 5.

Table 4. Native indicator species for sites 1–11 (western *Callitris*) and 12–25 (eastern *Eucalyptus*), arranged within columns by decreasing recording frequency.

Sites 1–11 (western *Callitris*)	Sites 12–25 (eastern *Eucalyptus*)
Einadia nutans	*Stipa densiflora*
Calandrinia eremaea	*Hardenbergia violacea*
Callitris glaucophylla	*Poa sieberiana*
Sida corrugata	*Luzula densiflora/meridionalis*
Goodenia pinnatifida	*Exocarpos cupressiformis*
Acacia deanei subsp. *paucijuga*	*Gonocarpus tetragynus*
Eucalyptus microcarpa	*Indigofera australis*
Acacia decora	*Poranthera microphylla*
Chamaesyce drummondii	*Stypandra glauca*
Allocasuarina luehmannii	*Eucalyptus polyanthemos*
Lepidium pseudohyssopifolium	*Eucalyptus macrorhyncha*
Enteropogon acicularis	*Hibbertia obustifolia*
Acacia montana	*Allocasuarina verticillata*
Chenopodium desertorum	*Cheilanthes austrotenuifolia*
Atriplex semibaccata	*Parietaria debilis*
Actinobole uliginosum	*Brunonia australis*
Myriocephalus rhizocephalus	*Acacia doratoxylon*
Pimelea curviflora	*Lepidosperma laterale*
Acacia hakeoides	*Bursaria spinosa*
Rhodanthe pygmaea	*Eucalyptus goniocalyx/nortonii*

Table 5. Native indicator species for sites 1–14 (excluding site 11) and sites 15–25, arranged within columns by decreasing recording frequency.

Sites 1–14 (excluding 11)	Sites 15–25
Einadia nutans	*Gonocarpus tetragynus*
Calotis cuneifolia	*Indigofera australis*
Callitris glaucophylla	*Poranthera microphylla*
Sida corrugata	*Eucalyptus polyanthemos*
Eucalyptus melliodora	*Eucalyptus macrorhyncha*
Goodenia pinnatifida	*Hibbertia obtusifolia*
Eucalyptus microcarpa	*Cheilanthes austrotenuifolia*
Acacia decora	*Brunonia australis*
Chamaesyce drummondii	*Acacia doratoxylon*
Allocasuarina luehmannii	*Lomandra filiformis*
Lepidium pseudohyssopifolium	*Lepidosperma laterale*
Enteropogon acicularis	*Carex appressa*
Acacia montana	*Eucalyptus goniocalyx/nortonii*
Chenopodium desertorum	*Lissanthe strigosa*
Atriplex semibaccata	*Microseris lanceolata*
Vittadinia cuneata	*Calytrix tetragona*
Actinobole uliginosum	*Brachyloma daphnoides*
Pimelea curviflora	*Xanthorrhoea glauca*
Acacia hakeoides	*Pterostylis nutans*
Calotis hispidula	*Galium gaudichaudii*

Moore (1953a) also briefly discussed some species which were indicative of rainfall levels. He noted that species of *Stipa* and *Danthonia* are found over a wide range of rainfall conditions, that several genera of the Chenopodiaceae are restricted to the drier areas, as is also shown in the present study (Tables 4 and 5, Appendix 1). He also noted a third less well-defined group which only occurred in areas of relatively high rainfall. Of the five species given by Moore (1953a) as examples of this group two (*Acacia pycnantha* and *Sebaea ovata*) were frequently found in the drier sites in the present study, two species (*Acacia acinacea* and *Acacia rubida*) were restricted to the wetter sites in the present study but were found at relatively few sites and only one species (*Brunonia australis*) occurs in Tables 4 and 5.

Influence of grazing intensity

The results show a correlation between degree of disturbance through grazing by domestic stock and the percentage of introduced species at a site. All the *Callitris glaucophylla* and *Eucalyptus camaldulensis* dominated sites have been routinely grazed by stock except for Ganmain Common and Coolamon Reserve. Ganmain Common was fenced on only two sides and thus stock were not kept in the area for long periods and it had the lowest percentage of weeds (30%) for the western sites. The easterly sites were mostly ungrazed and had, on average, a lower percentage of weed species (Table 3).

Sivertsen and Metcalfe (1995) noted that about 40% of plant species recorded for their Riparian/Floodplain remnants were exotics, an average 22% of species recorded in the Box and Cypress Pine remnants were exotics, and in the Mallee and Hills remnants an average of 14% of species were exotics. A similar trend was found in the present study with 49, 36 and 27% of species were exotics in sites 11 and 12 (floodplain), sites 1 to 10 (Cypress Pine) and sites 13–25 (Rocky Outcrops, Hills), respectively.

Given that grazing by domestic stock is detrimental to native vegetation it is unacceptable that most areas of public land, including Crown Land, in the SWS continue to be grazed without a Grazing Management Plan having been prepared and implemented. State Forests of NSW (Narrandera District) are now preparing Grazing Management Plans that seek to maintain or enhance biodiversity whilst reducing fuel loads (Wilson et al. 1997). The Albury Rural Lands Protection Board is implementing a similar approach for the management of their Stock Routes and Reserves. Such an approach should be adopted by managers of other public lands.

Additional species lists

An additional 23 species lists from a variety of sources were found for 16 of the 25 surveyed sites. The majority of these lists were not referred to in the floristic lists published by the National Herbarium of NSW. On average, four times more species were recorded in the present study than in previous surveys, thus it would appear that the species lists of the present study are relatively complete. However intensive, quadrat-based assessment of four of the *Callitris* dominated sites (sites 4, 5, 6 and 8) produced, on average, a 17% increase in the number of species recorded. Thus while the species lists of the present study are more comprehensive than those previously available they are not definitive.

Growth form analysis

As shown in the 'Growth Form' column of Appendix 1, of the 653 taxa identified to species or subspecies 194 (30%) were annuals, 7 (1%) were biennials, 295 (45%) were perennial herbs, 120 (18%) were shrubs and 37 (6%) were trees. Likewise Moore (1953a) found that for most of the seven alliances that he identified the life-form spectrum was dominated by hemicryptophytes (herbaceous perennials) and therophytes (annuals). These figures show that much of the plant biodiversity of this region was associated with the groundlayer and in the west where there were usually only one or two tree species in the overstorey and the shrub layer was almost non-existent the groundlayer can encompass over 95% of the plant species diversity. The perennial herbs were the dominant growth form and were comprised of species with various subterranean organs. During summer most of these species, except for some grasses and species such *Sida corrugata* and *Boerhavia dominii*, were dormant below ground level. Thus surveys conducted in the SWS during mid to late summer, autumn and much of winter for either scientific, commercial or legal reasons will produce a major underestimate of botanical diversity and could miss species for which there are specific responsibilities.

Of the annuals and biennials 65% were exotics, while only 12% of the perennials (perennial herbs, shrubs, trees) were exotics. Prober and Thiele (1995) found similar proportions in their study of the understorey of grassy *Eucalyptus albens* woodlands in the Central Western Slopes and noted this difference could be exploited when rehabilitating degraded remnants.

Conclusion

While the SWS is an area that has been extensively and intensively altered in the past 200 years, some areas of remnant vegetation still exist. Their relative rarity, particularly in the western half of the region, makes the protection of these areas all the more critical, and emphasises the need to identify and map them while investigating suitable conservation-based management strategies.

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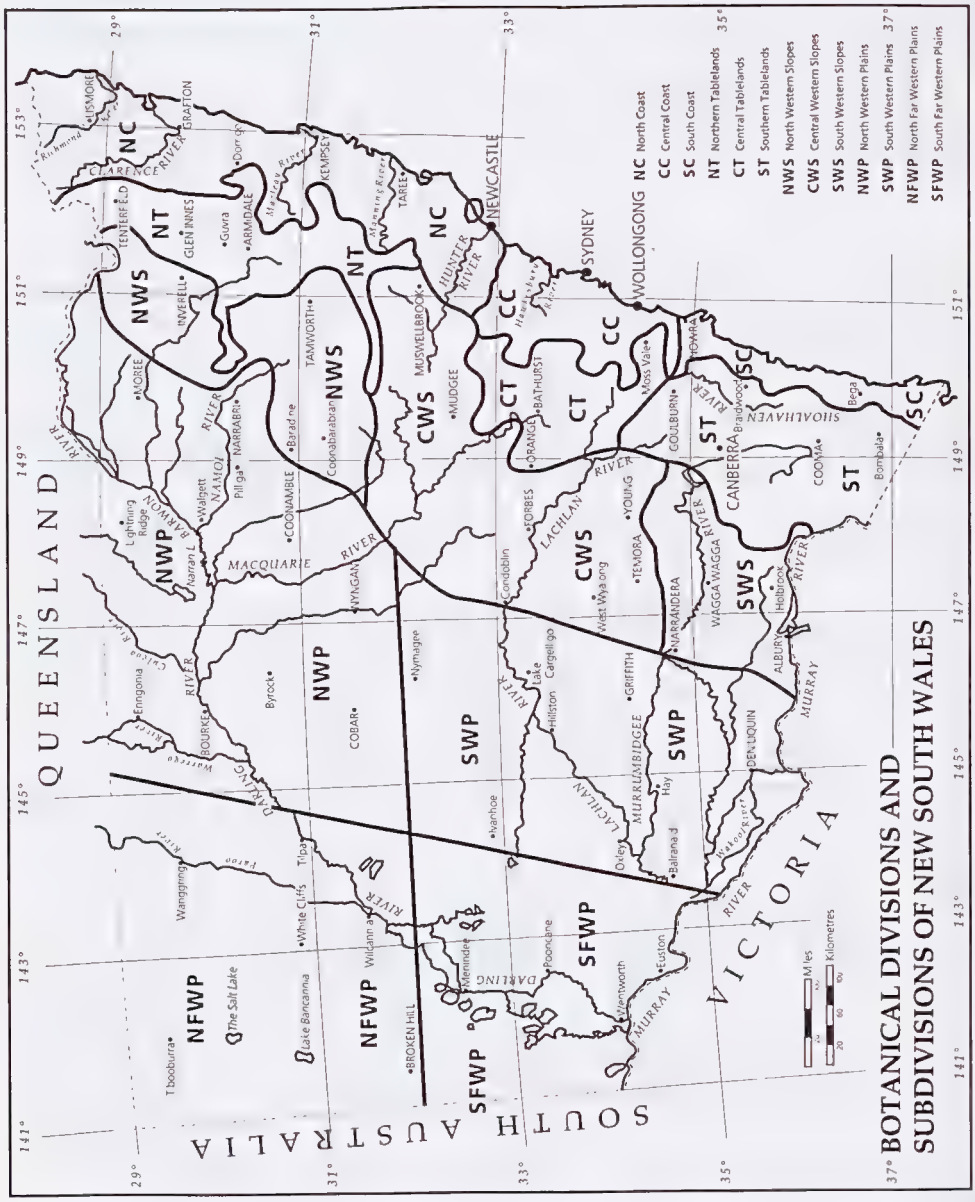

For explanation and description of the Botanical Divisions and Subdivisions of New South Wales see Anderson, R.H. (1961). Introduction, in *Contributions from the NSW National Herbarium*, Flora Series Nos 1–18.

Appendices

Appendix 1. Species records for various sites in the SWS, NSW

Plant species for 25 remnant vegetation sites in the South Western Slopes, NSW. Site abbreviations follow Table 2. A plus (+) in the site columns indicates a species has been recorded for a site, a question mark (?) indicates that a taxon was probably present at a site but flowering material was needed for positive identification. An asterisk (*) before a species name indicates a naturalised taxon. The growth form column (gf) indicates whether a species is an annual (a), biennial (bi), perennial herb (ph), shrub (s) or tree (t). The 'SWS' column indicates whether a taxon was recorded on the NSW Herbarium census database for the South Western Slopes, as per Harden (1990–1993), with yes (y) and no (N). For site information see table at the end of appendix 1 (page 314).

SPECIES	bro	mil	koc	mat	gan	les	kin	coo	wh	cur	bj	pom	mal	gh	fp	tt	pul	liv	tt	ben	mur	ell	tum	mun	ula	gf	SWS
Ferns & fern allies																											
ADIANTACEAE																											
Adiantum aethiopicum																				+	+	+	+		+	ph	N
ASPLENIACEAE																											
Asplenium flabellifolium																+			+	+	+	+	+		+	ph	y
Pleurosorus rutifolius /*subglandulosus*									+					+		+			+	+		+	+		+	ph	y
BLECHNACEAE																											
Blechnum minus																					+					ph	y
DENNSTAEDTIACEAE																											
Hypolepis rugosula																				+	+	+				ph	y
Pteridium esculentum															+					+	+	+				ph	y
MARSILEACEAE																											
Marsilea drummondii			+	+	+	+	+			+	+															ph	y
OPHIOGLOSSACEAE																											
Ophioglossum lusitanicum				+	+	+		+															+			ph	y
SINOPTERIDACEAE																											
Cheilanthes austrotenuifolia													+	+		+		+	+	+	+	+	+	+	+	ph	y
Cheilanthes distans													+	+		+						+				ph	y
Cheilanthes sieberi	+	+	+	+	+	+	+	+	+	+		+	+	+	+	+		+	+	+	+	+	+	+	+	ph	y
Pellaea falcata																			+	+			+		+	ph	N
Cycads & conifers																											
CUPRESSACEAE																											
Callitris endlicheri													+	+	+	+		+		+	+	+			+	t	y
Callitris glaucophylla	+	+	+	+	+	+	+	+	+	+	+	+	+	+		+										t	y
PINACEAE																											
**Pinus radiata*				?																	+					t	N
Monocotyledons																											
ALISMATACEAE																											
Damasonium minus		+		+						+																a	y
ALLIACEAE																											
**Nothoscordum borbonicum*										+																ph	y
ANTHERICACEAE																											
Arthropodium minus	+	+	+	+	+	+	+	+	+	+		+	+	+		+		+	+	+		+	+	+	+	ph	y
Caesia ?calliantha																						+				ph	y
Dichopogon fimbriatus		+						+															+			ph	y
Dichopogon strictus	+		+	+	+	+	+	+	+	+		+		+	+	+	+	+	+	+	+	+	+	+	+	ph	y
Laxmannia gracilis																		+							+	ph	N
Thysanotus patersonii		+			+	+		+				+	+			+	+	+	+	+	+	+	+	+	+	ph	y
Thysanotus tuberosus																	+				+					ph	y
Tricoryne elatior	+	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+	+	+		+	+		+	+	ph	y
ASPARAGACEAE																											
**Myrsiphyllum asparagoides*				+	+			+	+			+				+										ph	y
ASPHODELACEAE																											
Bulbine bulbosa	+	+	+	+	+	+	+	+		+		+	+	+		+	+	+	+	+	+	+	+		+	ph	y
Bulbine semibarbata					+									+		+										a	y

SPECIES	bro	mil	koc	mat	gan	les	kin	coo	wh	cur	bj	pom	mal	gh	fp	tr	pul	liv	tt	ben	mur	ell	tum	mun	ula	gf	SWS
CENTROLEPIDACEAE																											
Centrolepis strigosa													+			+					+					a	y
COLCHICACEAE																											
Burchardia umbellata												+						+	+		+	+	+		+	ph	y
Wurmbea dioica	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	ph	y
CYPERACEAE																											
Carex appressa										+	+						+		+	+	+	+	+	+	+	ph	y
Carex bichenoviana										+	+															ph	y
Carex breviculmis																			+			+				ph	N
Carex incomitata																							+			ph	y
Carex inversa		+	+	+	+	+	+		+	+	+	+		+		+						+	+		+	ph	y
Cyperus concinnus					+																					ph	N
**Cyperus eragrostis*				+						+	+	+	+								+	+				ph	y
Cyperus exaltatus											+															ph	y
Cyperus gunnii																									+	ph	y
Cyperus lhotskyanus					+																		+			ph	y
Cyperus lucidus																					+	?				ph	y
Cyperus sphaeroideus																							+			ph	y
**Cyperus tenellus*												+				+		+				+	+	+	+	a	y
Eleocharis acuta		+	+	+	+	+						+	+										+			ph	y
Eleocharis atricha																					+					ph	y
Eleocharis gracilis				+																						ph	N
Eleocharis plana										+																ph	y
Eleocharis pusilla										+	+															ph	y
Isolepis habra																					+					ph	N
Isolepis hookeriana				?		+							+	+	?		+	+	+	+	+				+	a	y
Isolepis inundata																								+		ph	y
Lepidosperma laterale													+	+		+		+	+		+	+	+	+	+	ph	y
Schoenus apogon		+						+				+		+	+	+	+	+	+	?	+	+	+	+	+	a	y
Schoenus latelaminatus																					+					a	y
HYPOXIDACEAE																											
Hypoxis glabella	+	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+	+	+	+	+	+	+	+	+	ph	y
Hypoxis vaginata																							+			ph	y
IRIDACEAE																											
**Freesia* sp.					+			+					+			+					+					ph	N
**Romulea minutiflora*		+		+																						ph	y
**Romulea rosea*	+	+	+	+		+	+		+	+	+	+	+	+		+	+	+	+	+	+			+	+	ph	y
JUNCACEAE																											
**Juncus acutus*																									+	ph	y
Juncus aridicola	+				+							+		?		+										ph	y
**Juncus bufonius*			+	+		+				+	+	+	+	+	+	+		+		+	+	+		+	+	a	y
**Juncus capitatus*	+			+		+		+		+					+	+		+		+	+	+	+	+	+	a	y
Juncus filicaulis																											
x *subsecundus*																		+								*ph*	*y*
Juncus flavidus		+		+			?	+			+	+									+					ph	y
Juncus fockei																					+					ph	y
Juncus holoschoenus														+	+		+		?						+	ph	y
Juncus homalocaulis				+																			+	+	+	ph	y
Juncus radula		+		+		+		+		+				+												ph	y
Juncus remotiflorus																		+				+			+	ph	y
Juncus sarophorus																					+	+	+			ph	y
Juncus subsecundus			+							?		+	?	+	+	+	+		+	?				+	+	ph	y
Juncus vaginatus																							+		+	ph	y
Luzula densiflora/meridionalis												+	+	+	+	+	+		+	+	+	+	+	+	+	ph	y
Luzula flaccida																		+								ph	y
JUNCAGINACEAE																											
Triglochin procerum										+																ph	y
LOMANDRACEAE																											
Lomandra effusa					+																					ph	y
Lomandra filiformis	+	+														+	?	+		?	+	+	+		+	ph	y
Lomandra longifolia																					+	+				ph	N
Lomandra multiflora	+	+	+	+	+	+	+	+	+	+		+	+	+	+		+	+	?		+	+		+		ph	y

SPECIES	bro	mil	koc	mat	gan	les	kin	coo	wh	cur	bj	pom	mal	gh	fp	tr	pul	liv	tt	ben	mur	ell	tum	mun	ula	gf	SWS
ORCHIDACEAE																											
Caladenia caerulea		+										+			+	+	+	+			+				+	ph	y
Caladenia cucullata															+				+	+		+				ph	y
Caladenia dimorpha																	+	+							+	ph	N
Caladenia fuscata		+		+	+	+	+	+					+	+	+	+	+	+	+	+	+	+	+	+	+	ph	y
Caladenia iridescens																				+						ph	N
Caladenia phaeoclavia		+			+	+		+						+				+				+			+	ph	y
Calochilus robertsonii																+	+	+	?	+				+		ph	y
Cyrtostylis reniformis														?	+	+			?	+				+	+	ph	y
Diuris goonooensis																								+		ph	y
Diuris tricolor	+		+	+		+		+		+																ph	N
Diuris sulphurea														+			+	+			+					ph	N
Diuris sp.															+	+						+	+		+	ph	?
Glossodia major		+		+	+	+	+	+					+	+	+	+	+	+	+	+	+		+	+	+	ph	y
Microtis unifolia	+	+	+	+	+	+	+	+		+			+	+	+	+	+	+	+		+	+	+	+	+	ph	y
Pterostylis curta																				+						ph	N
Pterostylis hispidula																	+									ph	N
Pterostylis mutica			+	+	+	+	+	+					+			+		+	?	+						ph	N
Pterostylis nana		+						?								+										ph	N
Pterostylis nutans														?				+	+	+	+	?	+		+	ph	N
Pterostylis pedunculata																	+		+							ph	N
Pterostylis setifera																			+							ph	y
Pterostylis sp. *B*																+										ph	N
Thelymitra ixioides			?														?	+								ph	N
Thelymitra megcalyptra																								?		ph	y
Thelymitra pauciflora		+										+	?	?							?		?		+	ph	y
PHORMIACEAE																											
Dianella longifolia		+		+	+			+				+		+												ph	y
Dianella revoluta					+	+	?	+	+	+		+		+		+	+	+	+	+		+	+	+	+	ph	y
Stypandra glauca												+	+	+	+	+		+		+	+	+	+	+	+	ph	y
POACEAE																											
Agrostis avenacea var. *avenacea*				+			+				+			+							+	+	+			a	y
**Aira cupaniana/elegantissima*	+	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+	+	+	+	+	+	+	+	+	a	y
**Alopecurus geniculatus*				+												+										ph	y
Amphibromus neesii		+				+										+								+		ph	y
Amphibromus nervosus										+															+	ph	N
**Anthoxanthum odoratum*																						+				ph	y
Aristida behriana	+		+	+	+	+	+	+	+	+			+	+	+			+			+			+	+	ph	y
Aristida calycina var. *praealta*									+																	ph	y
Aristida jerichoensis				+		+									+										+	ph	y
Aristida ramosa								+					+			+		?			+	+		+		ph	y
**Avena fatua*	+	+	+	+	+	+		+	+	+	+	+	+	+				+	+		+	+	+	+	+	a	y
Bothriochloa decipiens				+				+	+		+	+	+									+			+	ph	y
**Briza maxima*			+	+	+			+		+		+			+	+	+	+	+	+	+	+	+	+	+	a	y
**Briza minor*	+	+	+	+		+	+	+		+		+	+	+	+	+	+	+	+	+	+	+	+	+	+	a	y
**Bromus diandrus*				+	+			+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	a	y
**Bromus hordeaceus*			+							+			+	+				+							+	a	y
**Bromus madritensis*									+																	a	y
**Bromus molliformis*	+	+	+	+	+	+	+	+	+		+	+			+	+	+		+	+	+	+	+	+		a	y
**Bromus rubens*	+	+	+	+		+			+			+	+	+	+	+			+		+		+	+	+	a	y
**Bromus cartharticus*											+															a	y
Chionochloa pallida																	+	+			+	+	+			ph	y
Chloris truncata	+			+	+	+					+		+			+						+			+	ph	y
Cynodon dactylon			+	+			+	+		+	+							+		+	+	+			+	ph	y
**Cynosurus echinatus*																					+					a	y
Danthonia caespitosa												+														ph	y
Danthonia duttoniana				+																						ph	y
Danthonia eriantha	+	+	+		+	+	+	+		+			+	+	+				+		+	+	+	+		ph	y
Danthonia linkii var. *linkii*		+			+		+	+	+					+		+								+		ph	y
Danthonia monticola																+				+					+	ph	y
Danthonia racemosa								+									+							+		ph	y

SPECIES	bro	mil	koc	mat	gan	les	kin	coo	wh	cur	bj	pom	mal	gh	fp	tr	pul	liv	tt	ben	mur	ell	tum	mun	ula	gf	SWS
Danthonia setacea		+	+	+	+		+		+							+		+						+		ph	y
Danthonia tenuior													+													ph	y
Deyeuxia quadriseta																	+									ph	y
Dichelachne crinita		+																								ph	y
Dichelachne hirtella																							+			ph	y
Dichelachne micrantha					+			+														+	+	+	+	ph	y
Digitaria brownii																									+	ph	y
Digitaria divaricatissima						+		+	+			+														ph	y
**Echinochloa crus-galli*											+															a	y
Echinopogon ovatus																+		+	+			+	+		+	ph	y
**Ehrharta longiflora*									+			+		+												ph	y
**Eleusine tristachya*											+	+													+	a	y
Elymus scaber	+	+	+	+	+	+	+	+		+				+		+			+	+	+	+		+	+	ph	y
Enneapogon nigricans									+			+														ph	y
Enteropogon acicularis			+	+	+	+	+	+	+	+		+	+	+												ph	y
Eragrostis brownii				+		+				+		+	+		+							+			+	ph	y
**Eragrostis cilianensis*				+					+		+															a	y
Eragrostis parviflora											+							+							+	a	y
Eriochloa pseudoacrotricha				+																						a	y
**Holcus lanatus*																	+				+	+				ph	y
Homopholis proluta					+																					ph	y
**Hordeum leporinum*	+	+	+	+	+	+	+	+	+	+	+		+	+			+			+				+		a	y
**Lamarckia aurea*													+	+		+			+							a	y
**Lolium perenne/multiflorum*	+	+	+	+	+	+	+	+	+	+	+	+	+	+		+	+	+		+	+	+		+	+	a	y
**Panicum capillare*			+	+							+															a	y
Panicum effusum						+				+								+							+	ph	y
**Panicum schinzii*											+															a	N
Paspalidium aversum				+																						ph	y
Paspalidium constrictum				+										+												ph	N
Paspalidium jubiflorum											+	+														ph	y
**Paspalum dilatatum*				+					+	+	+										+				+	ph	y
Paspalum distichum											+															ph	y
**Pennisetum clandestinum*								+																		ph	y
**Pentaschistis airoides*			+	+	+			+		+			+							+	+	+				a	y
**Phalaris aquatica*												+					+								+	ph	y
**Phalaris minor*											+															a	y
**Phalaris paradoxa*				+			+			+				+												a	y
**Piptatherum miliacea*									+																	ph	y
**Poa annua*				+							+															a	y
**Poa bulbosa*								+	+	?	+		+							+				+		ph	y
Poa labillardieri		+			+	+	+	+		+										+						ph	y
Poa sieberiana												+	+	+	+	+	+	+	+	?	+	+	+		+	ph	y
**Polypogon monspeliensis*																					+	+		+		a	y
Pseudoraphis spinescens				+						?	+															ph	y
**Rostraria cristata*		+		+	+	+	+	+	+																	a	y
**Setaria gracilis*										+															+	ph	y
Sporobolus creber																									+	ph	y
Stipa aristiglumis				+			+																			ph	y
Stipa bigeniculata		+						+				+														ph	y
Stipa densiflora		+										+	+	+	+	+	+	+	+		+	+	+	+	+	ph	y
Stipa elegantissima				+	+	+		+																		ph	y
Stipa mollis									+									+	+					+		ph	y
Stipa nodosa	+								+			+														ph	y
Stipa scabra subsp. *falcata*		+	+	+	+	+	+	+		+	+		+	+	+	+	+	+		+	+	+	+	+	+	ph	y
Themeda australis												+								+	+	+	+	+	+	ph	y
**Vulpia bromoides*			+		+	+	+	+		+		+		+	+		+	+	+	+	+	+	+	+	+	a	y
**Vulpia muralis*	+																									a	y
**Vulpia myuros*		+		+					+								+									a	y
POTAMOGETONACEAE																											
Potamogeton tricarinatus										+																ph	y
TYPHACEAE																											

SPECIES	bro	mil	koc	mat	gan	les	kin	coo	wh	cur	bj	pom	mal	gh	fp	tr	pul	liv	tt	ben	mur	ell	tum	mun	ula	gf	SWS
XANTHORRHOEACEAE																											
Xanthorrhoea glauca subsp. *angustifolia*																+	+	+		+	+	+	+		+	ph	y
Dicotyledons																											
AMARANTHACEAE																											
Alternanthera denticulata		+		+						+	+	+		+								+			+	a	y
Alternanthera nana			+	+			+		?		+		+													a	y
**Amaranthus albus*											+															a	y
**Amaranthus hybridus*				+																						a	N
**Amaranthus retroflexus*									+																	a	y
Ptilotus macrocephalus	+		+																							ph	y
Ptilotus semilanatus	+			+	+																					ph	y
Ptilotus spathulatus	+	+		+					+					+												ph	y
ANACARDIACEAE																											
**Schinus areira*			+				+	+	+	+	+			+		+										t	N
APIACEAE																											
**Apium graveolens*																									+	bi	N
**Ciclospermum leptophyllum*																							+			a	y
Daucus glochidiatus	+	+	+	+	+	+	+	+		+		+	+	+	+	+	+	+	+	+	+	+	+	+	+	a	y
**Foeniculum vulgare*								+																		a	N
Hydrocotyle callicarpa		+										+						+	+			+				a	y
Hydrocotyle foveolata													+	+		+				+	+			+	+	a	y
Hydrocotyle laxiflora		+	+	+	+	+	+	+		+		+	+	+	+	+	+	+	+	+	+	+	+	+	+	ph	y
Hydrocotyle peduncularis																					+					ph	N
Oreomyrrhis eriopoda																							+			ph	y
Platysace lanceolata																									+	s	y
Trachymene cyanopetala														+		+										a	y
APOCYNACEAE																											
Parsonia eucalyptophylla														+												pc	y
ASTERACEAE																											
Actinobole uliginosum	+	+		+	+	+	+			+		+	+	+												a	y
Ammobium craspedioides																		+								ph	y
**Arctotheca calendula*	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	a	y
**Aster subulatus*											+															a	y
Brachycome angustifolia																				+					+	ph	y
Brachycome diversifolia /*curvicarpa*												+	?	+		+			+							ph	y
Brachycome gracilis	+	+		?	+		+	+							+			+	+							a	y
Brachycome lineariloba					+		+																			a	y
Brachycome multifida var. *multifida*												+				+										a	N
Brachycome papillosa					+																					ph	N
Brachycome perpusilla															+				+							a	y
Brachycome spathulata																					+		+			ph	y
Bracteantha bracteata				+		+	+																			a	y
Bracteantha viscosa		+	+		+			+				+	+	+				+	+	+	+		+	+	+	ph	y
Calotis cuneifolia	+	+	+	+	+	+	+	+	+	+		+		+		+	+	+								ph	y
Calotis hispidula	+			+	+	+	+	+	+				+													a	y
Calotis lappulacea					+		+	+		+		+				+						+			+	ph	y
Calotis scapigera											+															ph	y
**Carduus tenuiflorus* /*pycnocephalus*	+	+	+			+	+	+	+	+			+	+	+	+	+	+	+	+	+		+	+	+	a	y
**Carthamus lanatus*	+	+	+	+		+				+	+		+									+	+		+	a	y
Cassinia aculeata																				+						s	y
Cassinia arcuata																					+				+	s	y
Cassinia laevis																+										s	y
Cassinia longifolia																			+		+	+	+		+	s	y
Cassinia sp.					+												+							+		?	?
**Centaurea calcitrapa*				+																						a	y
**Centaurea melitensis*		+	+	+		+	+							+												a	y
**Centaurea solstitialis*									+																	a	y

SPECIES	bro	mil	koc	mat	gean	les	kin	coo	wh	cur	bj	pom	mal	gh	fp	tr	pul	liv	tt	ben	mur	ell	tum	mun	ula	gf	SWS
Centipeda cunninghamii		+		+			+			+	+	+		+											+	ph	y
Centipeda minima											+											+				a	y
**Chondrilla juncea*	?	?	+	+		+			+	+	+	+	+							+					+	ph	y
Chrysocephalum apiculatum	+	+	+	+	+	+	+	+		+		+		+	+	+			+		+	+	+	+	+	ph	y
Chrysocephalum semipapposum		+		+	+	+	+	+				+		+				+	+	+			+		+	ph	y
**Cichorium intybus*											+															ph	y
**Cirsium vulgare*	+	+		+		+				+	+	+		+	+		?	+		+	+	+	+		+	bi	y
**Conyza albida*										+												+	+	+	+	a	N
**Conyza bonariensis*				+	?	?					+	+		?		+									+	a	y
Cotula australis	+	+		+	+	+	+		+	+			+	+	+			+		+				+		a	N
**Cotula bipinnata*	+			+		+							+	+												a	y
Craspedia canens																						+				ph	y
Craspedia variabilis											+					+			+		+		+		+	ph	y
**Crepis foetida*													+									+	+			a	y
Cymbonotus lawsonianus					+	+		+						+			+	+	+	+	+	+	+	+	+	ph	y
**Gnaphalium americanum*																						+				a	N
Gnaphalium gymnocephalum																	+	+								ph	y
Gnaphalium indutum																				+						a	N
Gnaphalium sphaericum		+		+	+					+	+					+			?	?	+	+	+		?	a	y
**Hedypnois rhagadioloides*	+	+	+	+						+		+		+		+										a	y
Hyalosperma demissum															+	+			+	+					+	a	y
Hyalosperma semisterile	+					+	+	+																		a	y
**Hypochaeris radicata/glabra*	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	ph	y
Ixiolaena leptolepis					+											+										ph	N
**Lactuca serriola*				+					+	+	+			+											+	bi	y
Leptorhynchos elongatus																							+			ph	y
Leptorhynchos squamatus							+	+				+						+		+	+		+			ph	y
Microseris lanceolata																	+	+	+	+	+	+	+	+	+	ph	y
Minuria leptophylla	+			+	+		+	+	+																	ph	y
Myriocephalus rhizocephalus	+	+		+	+	+		+					+		+	+										a	y
Podolepis jaceoides																	+	+							?	ph	y
**Podospermum resedifolium*				+																						bi	N
Pseudognaphalium luteoalbum				+		+	?				+			+					+		+				+	a	y
Rhodanthe corymbiflora		+		+			+							+												a	y
Rhodanthe laevis	+															+										a	N
Rhodanthe pygmaea	+			+	+		+	+	+				+	+												a	y
Rutidosis multiflora		+														+		+		+						a	y
Senecio diaschides																					+					ph	N
Senecio garlandii															+	+			+	+					+	ph	y
Senecio hispidulus																				+	+	+	+	+	+	ph	y
Senecio lautus																			+	+						a	y
Senecio quadridentatus					+			+						+	+	+	+	?	+	+	+	+	+	+	+	ph	y
Sigesbeckia australiensis														+		+			+	+		+	+		+	a	y
**Silybum marianum*										+	+		+					+		+	+	+	+		+	bi	y
Solenogyne dominii		+		+	+	+	+	+			+	+	+		+			+		+	+	+	+		+	ph	y
**Soliva sessilis*																+				+	+	+				a	y
**Soliva stolonifera*						+		+																		a	y
**Sonchus asper*		+		+		+				+									+	+	+		+	+	+	a	y
**Sonchus oleraceus*	+	+	+	+	+	+	+	+	+	+	+	+		+						+		+	+		+	a	y
Stuartina muelleri		+	+	+	+	+	+	+	+			+	+	+	+	+		+	+	+	+	+	+	+	+	a	y
**Taraxacum officinale*				+	+	+																				ph	y
**Tolpis umbellata*			+										+					+			+	+	+	+	+	a	y
Triptilodiscus pygmaeus	+	+	+	+	+	+	+	+		+		+	+	+	+	+		+	+	+	+	+	+	+	+	a	y
Vittadinia cervicularis					+																					a	N
Vittadinia cuneata			+	+		+	+	+	+	+		+						+					+			a	y
Vittadinia gracilis	+	+	+	+						+		+	?												+	s	y
Vittadinia sp.												?		+								+				?	?
**Xanthium spinosum*				+						+	+															a	N
BORANGINACEAE																											
**Amsinckia intermedia*				+	+	+		+	+	+	+		+	+			+									a	y
Cynoglossum australe																									+	ph	N

SPECIES	bro	mil	koc	mat	gan	les	kin	coo	wh	cur	bj	pom	mal	gh	fp	tr	pul	liv	tt	ben	mur	ell	tum	mun	ula	gf	SWS
Cynoglossum suaveolens		+						+				+		+		+	+	+		+	+		+	+		ph	y
**Echium plantagineum*	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+	+	+	a	y
**Heliotropium europaeum*				+					+		+	+														a	y
Myosotis australis																			+					+		a	y
**Myosotis discolor*												+								+					+	a	y
Myosotis sp.															+	+		+			+	+	+			?	?
BRASSICACEAE																											
**Brassica rapa*								+																		a	y
**Capsella bursa-pastoris*					+			+			+			+												a	y
**Cardamine hirsuta*																+				+						a	y
Cardamine paucijuga																					+	+				a	y
Lepidium pseudohyssopifolium		+	+	+	+	+		+	+	+		+		+		+										a	y
**Raphanus raphanistrum*									+																	a	y
Rorippa laciniata											+															ph	y
**Rorippa nasturtium -aquaticum*																						+	+			ph	N
**Rorippa palustris*											+															a	y
**Sisymbrium erysimoides*					+	+																				a	N
**Sisymbrium officinale*									+				+			+					+					a	N
**Sisymbrium orientale*							+																			a	y
CACTACEAE																											
**Opuntia* sp.					+																					ph	?
CALLITRICHACEAE																											
**Callitriche stagnalis*										+										+	+		+			a	N
CAMPANULACEAE																											
Wahlenbergia communis					+			+				+				+										ph	y
Wahlenbergia gracilenta	+			+	+	+	+	+				+	+			+				+	+					a	y
Wahlenbergia gracilis																		+				+				ph	y
Wahlenbergia stricta	+	+	+	+		+	+		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	ph	y
CARYOPHYLLACEAE																											
**Cerastium glomeratum*	+	+	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+	+	+	+	+	+	+	+	a	y
**Moenchia erecta*	+			+		+			+	+			+	+		+	+	+	+	+		+		+	+	a	y
**Petrorhagia nanteuilii*																+										a	y
**Petrorhagia velutina*	+	+	+	+	+	+	+	+	+	+		+	+	+	+	+		+	+	+	+	+	+	+	+	a	y
**Polycarpon tetraphyllum*										+												+				a	N
**Silene gallica*			+	+		+		+		+		+	+	+	+	+		+		+		+	+		+	a	y
**Spergularia rubra*				+	+	+	+																			a	y
**Stellaria media*					+	+	+	+	+	+			+	+		+		+	+	+	+	+	+	+	+	a	y
Stellaria pungens																			+		+	+	+		?	ph	y
CASUARINACEAE																											
Allocasuarina luehmannii	+	+	+	+	?	+	+			+	+			+		+										t	y
Allocasuarina verticillata									+			+	+	+	+	+		+	+	+	+				+	t	y
Casuarina cunninghamiana										+																t	y
CHENOPODIACEAE																											
Atriplex semibaccata	+		?	?	+	?	+	?		+			+	+												ph	y
Atriplex spinibractea				+																						ph	y
**Chenopodium album*				?					+																	a	y
Chenopodium desertorum subsp. *microphyllum*	?	?	+	+	+	+	+	+		+				+												ph	y
Chenopodium pumilo				+					+			+													+	a	y
Einadia hastata					+		+									+								+		ph	N
Einadia nutans	+	+	+	+	+	+	+	+	+	+	+	+	+	+		+									+	ph	y
Enchylaena tomentosa				?	+																					s	N
Maireana decalvens				+																						s	y
Maireana enchyaenoides				+							+															s	y
Maireana humillima	+		?	+	+	?	?							?												s	y
Maireana microphylla				+								+													+	s	N
Sclerolaena muricata				+						+	+															s	y
CLUSIACEAE																											
Hypericum gramineum				+															+		+	+	+			ph	y
**Hypericum perforatum*			+		+		+	+		+	+	+					+	+	+	+	+			+	+	ph	y

SPECIES	bro	mil	koc	mat	gan	les	kin	coo	wh	cur	bj	pom	mal	gh	fp	tr	pul	liv	tt	ben	mur	ell	tum	mun	ula	gf	SWS
CONVOLVULACEAE																											
**Convolvulus arvensis*																									+	ph	y
Convolvulus erubescens	+		+	+	+	+	+	+	+	+		+	+	+				+	+	+	+	+	+		+	ph	y
**Cuscuta campestris*																+										a	y
Dichondra repens	+		+	+		+		+		+	+		+	+						+	+	+	+		+	ph	y
Evolvulus alsinoides var. *decumbens*														+												ph	N
CRASSULACEAE																											
Crassula colorata	+							?	+				+													a	y
Crassula decumbens			+	+	+	+			+	+	+		+				+	+	+	+		+		+		a	y
Crassula sieberiana	+	+	+	+	+	+	+			+		?		+	+	+		+	+	+	?				?	a	y
CUCURBITACEAE																											
**Cucumis myriocarpus*				+					+		+	+		+											+	a	y
DILLENIACEAE																											
Hibbertia obtusifolia															+	+	+	+	+	+	+	+	+	+	+	s	y
Hibbertia riparia																	+	+								s	y
Hibbertia sericea															+	+					+				+	s	y
DROSERACEAE																											
Drosera glanduligera	+	+	+	+		+				+			+		+	+		+								a	y
Drosera peltata	+	+	+	+		+	+	+		+		+	+	+	+	+	+	+	+	+	+	+	+	+	+	ph	y
ELATINACEAE																											
Elatine gratioloides										+			+													a	y
EPACRIDACEAE																											
Acrotriche serrulata																					+				+	s	N
Astroloma humifusum																+										s	y
Brachyloma daphnoides															+	+	+	+			+	+	+		+	s	y
Leucopogon attenuatus																		+			+				+	s	y
Leucopogon virgatus																	+	+							+	s	y
Lissanthe strigosa															+	+	+	+	+	+			+	+	+	s	y
Melichrus urceolatus												+		+			+	+			+		+		+	s	y
EUPHORBIACEAE																											
Beyeria viscosa																+										s	y
Chamaesyce drummondii	+			+	+		+	+		+	+	+		+	+										+	ph	y
Phyllanthus hirtellus																+	+		+					+	+	s	y
Poranthera microphylla														+	+	+	+		+	+	+	+	+	+	+	a	y
**Ricinus communis*												+														s	y
FABACEAE																											
Caesalpinioideae																											
Senna artemisioides subsp. *zygophylla*				+	+	+								+												s	y
Faboideae																											
Bossiaea prostrata																				+			+			s	N
**Chamaecytisus palmensis*								+													+					s	N
Daviesia latifolia																		+		+	+				+	s	y
Daviesia leptophylla																	+	+			+	+		+	+	s	y
Daviesia mimosoides																					+				?	s	N
Daviesia ulicifolia	+												+													s	y
Desmodium varians							+						+								+		+			ph	y
Dillwynia juniperina								+	+							+		+		+						s	N
Dillwynia phylicoides																	+	+		+	+		+			s	y
Dillwynia sericea	+							+				+	+		+	+	+	+	+	+	+	+	+	+	+	s	y
Eutaxia microphylla/diffusa	+	+	+					+																		s	y
Glycine canescens						?	+	+	+				+	+		+					?	?				ph	y
Glycine clandestina				+		?	+			+		?	+	+	+			?	+	+	+	+	+		+	ph	y
Glycine tabacina	+				+					+																ph	y
Glycine sp.																	+							+		?	?
**Glycyrrhiza glabra*										+																ph	y
Gompholobium huegelii																	+									s	y
Goodia medicaginea															+				+							s	y
Hardenbergia violacea								+					+	+	+			+	+	+	+	+	+	+	+	s	y
Hovea linearis																			+			+		+	+	s	y

SPECIES	bro	mil	koc	mat	gan	les	kin	coo	wh	cur	bj	pom	mal	gh	fp	tr	pul	liv	tt	ben	mur	ell	tum	mun	ula	gf	SWS
Indigofera adesmiifolia												+		+		+			+	+			+		+	s	y
Indigofera australis												+		+	+	+	+	+		+	+	+	+	+	+	s	y
**Medicago minima*	+			+	+	+	+	+	+					+												a	y
**Medicago polymorpha*			+	+	+	+		+	+	+	+		+			+										a	y
Platylobium formosum																	+		+	+	+		+		+	s	y
Pultenaea boormanii																								?		s	N
Pultenaea cunninghamii																			+				+		+	s	y
Pultenaea foliolosa												+		+	+	+	+	+		+	+					s	y
Pultenaea humilis																					+					s	N
Pultenaea largiflorens														+		+										s	N
Pultenaea laxiflora																									+	s	y
Pultenaea polifolia																									+	s	N
Pultenaea procumbens												+							+			+	+			s	y
Swainsona procumbens				+																						ph	y
Templetonia stenophylla		+		+	+			+				+														s	y
**Trifolium angustifolium*	+	+	+	+	+	+	+	+	+	+	+	+	+	+							+	+	+	+	+	a	y
**Trifolium arvense*	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+		+	a	y
**Trifolium campestre*	+	+	+	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+	+	+	+	+	+	+	a	y
**Trifolium cernuum*				+		+	+														?	+				a	y
**Trifolium dubium*		+	+	+		+	+	+		+	+		+					+	+	+	+	+	+		+	a	y
**Trifolium glomeratum*		+	+	+	+	+	+	+	+	+	+		+	+	+	+		+		+	+	+	+	+	+	a	y
**Trifolium hirtum*														+												a	y
**Trifolium repens*				+						+			+								+				+	ph	y
**Trifolium striatum*	+			+	+	+		+		+	+							+			+	+				a	y
**Trifolium subterraneum*	+	+	+	+	+	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+	+			+	a	y
**Trifolium tomentosum*		+		+	+	+	+	+		+				+		+										a	y
**Vicia sativa*									+	+						+			+							a	y
**Vicia villosa*														+												a	y
Mimosoideae																											
Acacia acinacea												+				+										s	y
Acacia amblygona																								+		s	N
Acacia baileyana								+																	+	t	y
Acacia brachybotrya				+						+																s	y
Acacia buxifolia								+									+	+			+		+		+	s	y
Acacia dealbata																	+				+	+	+			t	y
Acacia deanei subsp. *paucijuga*	+			+	+		+	+	+		+		+	+	+	+				+						t	y
Acacia decora	+			+	+	+	+		+			+	+	+	+		+								+	s	y
Acacia difformis																	+									t	y
Acacia doratoxylon														+	+	+	+		+	+	+	+		+		+	t	y
Acacia genistifolia													+			+			+		+				+	+	s	y
Acacia gunnii																	+		+			+			+	s	y
Acacia hakeoides	+	+	+	+	+	+	+	+																		s	y
Acacia implexa										+				+		+			+	+	+	+		+		+	t	y
Acacia lanigera							+									+		+				+				s	y
Acacia leucoclada										+																t	y
Acacia linearifolia																	+									t	y
Acacia montana	+	+	+	+	+	+	+	+			+				+											s	y
Acacia oswaldii					?			+																		s	y
Acacia paradoxa								+					+	+			+		+			+	+	+	+	s	y
Acacia pycnantha	+	+				+			+				+	+	+	+	+			+	+				+	t	y
Acacia rubida																				+	+					t	y
Acacia ulicifolia																								+		s	N
Acacia verniciflua	+												+			+	+				+				+	s	y
FUMARIACEAE																											
**Fumaria capreolata*						+		?	+				+													a	y
**Fumaria densiflora*																	+									a	y
**Fumaria muralis*					+					+				+	+											a	y
**Fumaria* sp.				+			+				+															?	?
GENTIANACEAE																											
**Centaurium erythraea* /*tenuiflorum*	+	+	+	+	+	+	+	+			+			+	+	+	+	+	+	+	+	+	+	+	+	a	y

SPECIES	bro	mil	koc	mat	gan	les	kin	coo	wh	cur	bj	pom	mal	gh	fp	tr	pul	liv	tt	ben	mur	ell	tum	mun	ula	gf	SWS
**Cicendia quadrangularis*	+	+		+		+							+			+		+	+	+	+			+	+	a	y
Sebaea ovata	+		+	+		+	+	+								+		+		+	+		+	+		a	y
GERANIACEAE																											
**Erodium botrys*				+		+	?		+	+	+	+	+				+			+					+	a	y
**Erodium cicutarium*	+	+		+		+	+			+						+										a	y
Erodium crinitum	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+			+						+	a	y
**Erodium moschatum*					+	+			+	+																a	y
**Geranium molle*								+	+				+					?		+		+	+			a	y
Geranium retrorsum			+			+		+				+														ph	y
Geranium solanderi	+	+		+	+		+			+			+	+	+	+	+	+	+	+	+	+	+	+	+	ph	y
Pelargonium australe																			+	+		+				ph	y
GOODENIACEAE																											
Brunonia australis												+					+	+	+	+	+	+	+	+	+	ph	y
Dampiera lanceolata																+										s	y
Dampiera purpurea																									+	s	y
Goodenia gracilis				+							+														+	ph	y
Goodenia hederacea			+	+	+	+	+	+		+			+		+	+	+	+		+	+	+	+	+	+	ph	N
Goodenia heteromera	+	+																								a	N
Goodenia ovata																+										s	y
Goodenia pinnatifida	+	+	+	+	+	+	+	+	+	+		+		+			+									a	y
Goodenia pusilliflora			+	+	+	+	+	+																		a	y
Velleia paradoxa												+								+						ph	y
HALORAGACEAE																											
Gonocarpus elatus							+		+			+	+	+	+	+		+	+	+		+		+	+	ph	y
Gonocarpus tetragynus												+			+	+	+	+	+	+	+	+	+	+	+	ph	y
Haloragis aspera										+																ph	N
Haloragis heterophylla																					+		+			ph	y
Myriophyllum sp.										+	+															a	?
LAMIACEAE																											
Ajuga australis						+		+						+		+		+	+	+	+	+	+		+	ph	y
**Marrubium vulgare*				+		+			+	+	+	+	+	+		+		+		+	+	+		?	+	ph	y
Mentha diemenica			+																				+			ph	y
**Mentha pulegium*				+						+	+											?				ph	y
Prostanthera granitica																		+								s	N
Prostanthera ?denticulata																			+							s	N
Prostanthera ovalifolia																+										s	N
Salvia plebeia																							+			ph	N
**Salvia verbenaca*	+			+	+	+	+	+	+	+		+	+					+		+					+	ph	y
Scutellaria humilis													+			+			+	+		+	+		+	ph	y
**Stachys arvensis*		+	+	+						+	+	+	+								+	+	+			a	N
LAURACEAE																											
Cassytha melantha															+	?		+				+				ph	y
Cassytha pubescens																		+	?		?				+	ph	N
LENTIBULARIACEAE																											
Utricularia dichotoma																					+					ph	y
LINACEAE																											
**Linum usitatissimum*	+	+						+															+			a	y
LOBELIACEAE																											
Isotoma axillaris									+					+		+		+	+	+	+	+			+	ph	y
Isotoma fluviatilis															+		+			+	+	+	+			ph	y
Lobelia gibbosa		+														+		+					+			ph	y
Pratia concolor				+	+	+				+	+															ph	y
LORANTHACEAE																											
Amyema linophyllum			+	+							+															s	y
Amyema miquelii									+		+	+	+	+	+	+		+			+			+	+	s	y
Amyema pendulum																+				?		+				s	y
Amyema miraculosum											?			+												s	y
Muellerina eucalyptoides													+		+	+								+		s	y
LYTHRACEAE																											
Lythrum hyssopifolia		+	+	+		+				+	+	+	+	+		+	+			+	+	+		+	+	a	y
MALVACEAE																											
**Malva parviflora*				+		+		+		+	+		+												+	a	N

SPECIES	bro	mil	koc	mat	gan	les	kin	coo	wh	cur	bj	pom	mal	gh	fp	tr	pul	liv	tt	ben	mur	ell	tum	mun	ula	gf	SWS
**Modiola caroliniana*										+	+	+										+				ph	y
Sida corrugata	+	+	+	+	+	+	+	+	+	+	+	+	+	+												ph	y
Sida trichopoda											+															ph	y
MELIACEAE																											
Melia azedarach								+	+																	t	N
MENYANTHACEAE																											
Nymphoides crenata										+																ph	N
MYOPORACEAE																											
Eremophila debilis				+	+		+																			s	y
Myoporum montanum								+																		s	y
Myoporum platycarpum subsp. *perbellum*							+																			s	N
MYRTACEAE																											
Callistemon sieberi																						+			+	s	y
Calytrix tetragona															+	+	+		+	+	+	+			+	s	y
Eucalyptus albens			+			+	+	+				+	+			+	+	+	+		+	+	+	+	+	t	y
Eucalyptus blakelyi									+	+		+	+	+	+	+		+	+	+	+	+		+	+	t	y
Eucalyptus bridgesiana																						+			+	t	y
Eucalyptus camaldulensis				+			+			+	+															t	y
Eucalyptus dwyeri																	+			+						t	y
Eucalyptus goniocalyx/nortonii																		+	+	+	+	+	+	+	+	t	y
Eucalyptus macrorhyncha																+	+	+	+	+	+	+	+	+	+	t	y
Eucalyptus melliodora	+	+		+		+	+		+	+	+	+	+	+							+				+	t	y
Eucalyptus microcarpa			+	+	+	+	+	+		+	+	+	+	+			+									t	y
Eucalyptus polyanthemos																+	+	+	+	+	+	+	+	+	+	t	y
Eucalyptus rossii																		+	+			+		+		t	y
Eucalyptus sideroxylon																			+			+	+	+	+	t	y
Kunzea parvifolia																									+	s	y
Leptospermum brevipes																				+						s	N
Leptospermum continentale																			+		+	+		+		s	y
Leptospermum multicaule																		+	+			+	?		+	s	y
Micromyrtus ciliata																				+						s	N
NYCTAGINACEAE																											
Boerhavia dominii					+				+		+		+	+												ph	y
OLEACEAE																											
**Olea europea*								+	+			+	+													t	N
ONAGRACEAE																											
Epilobium billardierianum subsp. *cinereum*											+				?								+	+		ph	y
Epilobium hirtigerum					+					+															+	ph	y
Ludwigia peploides										+	+	+														ph	y
**Oenothera stricta*										+																a	y
OXALIDACEAE																											
Oxalis perennans	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	ph	N
**Oxalis pes-caprae*					+	+	+	+	+	+			+				+									ph	y
PAPAVERACEAE																											
**Papaver somniferum* subsp. *setigerum*							+			+			+													a	y
PHYTOLACCACEAE																											
**Phytolacca octandra*																							+			ph	N
PITTOSPORACEAE																											
Bursaria spinosa						+						+	+	+		+		+		+		+			+	s	N
Cheiranthera cyanea																		+	+	+	+	+	+	+		s	y
Pittosporum phylliraeoides							+		+				+	+												s	N
PLANTAGINACEAE																											
**Plantago lanceolata*						+			+													+				a	y
Plantago varia	+	+				+		+			+		+		+		+	+				+	+		+	ph	y
POLYGONACEAE																											
**Acetosella vulgaris*											+					+			+		+	+	+		+	ph	y
Persicaria lapathifolia											?	+														a	y
Persicaria prostrata					+						+	+	+		+								+		+	ph	y
**Polygonum aviculare*					+				+	+	+	+	+	+												a	y

SPECIES	bro	mil	koc	mat	gan	les	kin	coo	wh	cur	bj	pom	mal	gh	fp	tr	pul	liv	tt	ben	mur	ell	tum	mun	ula	gf	SWS
Polygonum plebeium														+												a	N
Rumex brownii	+	+	+	+		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	ph	y
**Rumex conglomeratus*																						+	+			ph	y
**Rumex crispus*				+				+	+	+	+											+			+	ph	y
Rumex tenax				+	+	+	+			+																ph	y
PORTULACACEAE																											
Calandrinia eremaea	+	+	+	+	+	+	+	+	+	+				+	+	+			?			+				a	y
Montia fontana																				+						a	y
Portulaca oleracea									+		+															a	N
PRIMULACEAE																											
**Anagallis arvensis*	+	+		+		+	+	+	+	+	+	+	+		+	+	+	+	+	+	+	+	+	+	+	a	N
PROTEACEAE																											
Grevillea alpina																				+						s	y
Grevillea floribunda														+	+	+		+							+	s	y
Grevillea lanigera																	+	+							+	s	y
Grevillea polybractea																	+	+			+					s	y
Hakea leucoptera				+										+												s	N
Hakea tephrosperma						+				+															+	s	N
Persoonia rigida																	+	+			+				+	s	y
RANUNCULACEAE																											
Clematis microphylla var. *microphylla*				+																						s	N
Ranunculus lappaceus	+	+		+			+	+		+	+	+		+	+	+	+	+	+	+	+	+	+	+	+	ph	y
**Ranunculus muricatus*				+			+			+										+	+	+	+			a	y
Ranunculus pumilo											+															a	y
**Ranunculus sceleratus*										+		?														a	y
Ranunculus sessiliflorus		+	+	+	+	+	+	+		+			+	+	+	+	+	+		+	+	+	+	+	+	a	y
**Ranunculus trilobus*											+															a	N
Ranunculus undosus										+	+															ph	N
RHAMNACEAE																											
Cryptandra amara												+			+	+									+	s	y
Spyridium parvifolium																				+		+	+	+		s	y
ROSACEAE																											
Acaena novae-zelandiae																					+	+	+			ph	N
Acaena ovina									+			+						+			+	+	+		+	ph	y
Aphanes australiana				+	+	+		+	+		+									+						a	y
**Potentilla recta*																					+					ph	y
**Rosa rubiginosa*				+						+	+															s	y
**Rubus 'fruticosus'*																		+		+	+				+	s	N
**Sanguisorba minor*												+														ph	y
RUBIACEAE																											
Asperula conferta			+		+						+	+		+	+	+	+	+	+	+	+				+	ph	y
**Galium aparine*								+								+			+	+					+	a	y
**Galium divaricatum*				+		+		+					+								+	+				a	y
Galium gaudichaudii																+		+		+	+	+	+		+	ph	y
**Galium murale*							+																			a	y
Galium propinquum													+													a	y
Opercularia hispida																					+	+		+		ph	y
Opercularia varia																		+							+	ph	y
Pomax umbellata																+		+					+		+	s	N
**Sherardia arvensis*	+	+		+		+	+	+	+	+	+	+	+			+	+	+	+	+	+	+	+	+	+	a	y
RUTACEAE																											
Correa reflexa																		+	+	+						s	y
Eriostemon myoporoides														+												s	y
Geijera parviflora														+												t	N
Zieria aspalathoides																+									+	s	y
Zieria cytisoides																+										s	y
SALICACEAE																											
**Salix babylonica*										+																t	y

SPECIES	bro	mil	koc	mat	gan	les	kin	coo	wh	cur	bj	pom	mal	gh	fp	tr	pul	liv	tt	ben	mur	ell	tum	mun	ula	gf	SWS
SANTALACEAE																											
Exocarpos cupressiformis		+										+	+	+		+	+	+	+	+	+			+	+	t	y
Santalum acuminatum														+		+										s	y
Santalum lanceolatum													+													s	N
SAPINDACEAE																											
Alectryon oleifolius subsp. *elongatus*							+																			t	N
Dodonaea boroniifolia													+		+											s	y
D. viscosa subsp. *angustifolia*																					+		?			s	N
D. viscosa subsp. *angustissima*																					+	+	+		+	s	y
D. viscosa subsp. *cuneata*	+	+	+	+	+	+	+	+						+	+	+			+	+					+	s	y
SCROPHULARIACEAE																											
Derwentia perfoliata																									+	s	y
Gratiola pendunculata																									+	ph	N
Gratiola peruviana																+				?	+	+	+			ph	N
**Kickxia elatine*											+															ph	y
Limosella australis				+																+						ph	y
Limosella curdieana	+					+							+													ph	y
**Linaria pelisseriana*						+				+			+		+	+	+	+	+	+	+	+	+	+	+	a	y
Mimulus gracilis											+															ph	y
**Orobanche minor*		+	+		+	+	+	+	+	+		+	+	+		+	+	+	+		+	+	+		+	a	y
**Parentucellia latifolia*	+	+	+	+	+	+	+	+		+		+	+	+	+	+		+	+	+		+		+	+	a	y
**Verbascum thapus*				+																						bi	N
**Verbascum virgatum*									+	+		+	+	+	+			+	+	+	+	+	?		+	bi	y
**Veronica anagallis-aquatica*																							+			ph	y
**Veronica arvensis*																			+	+						a	y
**Veronica peregrina*				+							+															a	y
Veronica plebeia																+					+					ph	N
SIMAROUBACEAE																											
**Ailanthus altissima*									+	+												+				t	y
SOLANACEAE																											
Cyphanthera albicans																+										s	y
**Lycium ferocissimum*	+		+	+	+	+	+		+	+		+	+													s	y
Solanum cinereum						+															+		+		+	s	y
Solanum esuriale				+					+					+												ph	y
**Solanum nigrum*									+	+	+	+		+		+			+	+		+		+	+	ph	y
**Solanum pseudocapsicum*										+																s	y
STACKHOUSIACEAE																											
Stackhousia monogyna	+	+	+	+	+	+	+	+		+		+		+	+	+	+	+	+				+		+	ph	y
STERCULIACEAE																											
Brachychiton populneus					+	+		+	+	+		+	+	+	+	+		+	+	+	+	+	+		+	t	y
STYLIDIACEAE																											
Levenhookia dubia	+	+		+	+	+		+				+				+		+	+	+					+	a	y
Stylidium despectum																+				+	+					a	y
Stylidium graminifolium																	+									ph	y
THYMELAEACEAE																											
Pimelea curviflora	+	+		+	+	+		+				+		+												s	y
Pimelea linifolia		+		+	+								+	+	+	+	+	+		+				+	+	s	y
URTICACEAE																											
Parietaria debilis									+				+	+	+	+			+	+		+	+		+	a	y
**Urtica urens*						+	+	+		+	+		+	+		+				+		+			+	a	N
VERBENACEAE																											
**Phyla nodiflora*										+	+															ph	N
**Verbena bonariensis*											+	+										+	+			ph	y
**Verbena officinalis*										+	+														+	ph	y
**Verbena supina*										+																ph	N
VIOLACEAE																											
Hybanthus monopetalus														+		+									+	ph	N
Viola betonicifolia											+												+			ph	N
ZYGOPHYLLACEAE																											
**Tribulus terrestris*				+					+		+															a	y

Sites		Total number of taxa	Number naturalised	Percentage naturalised	Number of native taxa
Brookong SF	bro	114	38	33.3	76
Milbrulong SF	mil	131	40	30.5	91
Kockibitoo SF	koc	117	42	35.9	75
Matong SF	mat	221	86	38.9	135
Ganmain Reserve	gan	152	45	29.6	107
Lester SF	les	167	63	37.7	104
Kindra SF	kin	145	46	31.7	99
Coolamon Reserve	coo	163	61	37.4	102
Winery Hill	wh	129	64	49.6	65
Currawananna SF	cur	184	89	48.4	95
Berry Jerry SF	bj	135	69	51.1	66
Pomingalarna Park	pom	165	53	32.1	112
Malebo Range	mal	164	61	37.2	103
Galore Hill Reserve	gh	191	51	26.7	140
Flowerpot Hill	fp	117	26	22.2	91
The Rock NR	tr	213	54	25.4	159
Pulletop SF	pul	119	28	23.5	91
Livingstone SF	liv	190	44	23.2	146
Tabletop NR	tt	153	36	23.5	117
Benambra SF	ben	191	55	28.8	136
Murraguldrie SF	mur	221	61	27.6	160
Ellerslie SF	ell	199	64	32.2	135
Tumblong SF	tum	186	48	25.8	138
Mundarlo Road	mun	132	38	28.8	94
Ulandra NR	ula	258	68	26.4	190

Appendix 2. Number of survey trips per site and year/s of survey trips

Site No.	Site	No. survey trips	Year/s of survey trips
1	Brookong SF	4	Sept–Dec 1992
2	Milbrulong SF	4	Sept–Dec 1992
3	Kockibitoo SF	4	Sept–Dec 1992
4	Matong SF	9	Nov 1994–Oct 1995, Aug–Nov 1996
5	Ganmain Reserve	7	Sept–Dec 1992, Aug–Nov 1996
6	Lester SF	8	Sept–Dec 1993, Aug–Nov 1996
7	Kindra SF	4	Sept–Nov 1992
8	Coolamon Reserve	9	Sept–Nov 1992, Aug–Nov 1996
9	Winery Hill	30+	1991, 1992
10	Currawananna SF	6	Sept–Dec 1993, Oct–Nov 1995
11	Berry Jerry SF	10	Sept 1994–Sept 1995
12	Pomingalarna Park	30+	1990, 1991
13	Malebo Range	7	Sept–Nov 1995
14	Galore Hill Reserve	10+	1992, 1993
15	Flowerpot Hill	3	Sept–Dec 1992
16	The Rock NR	30+	1988–1990
17	Pulletop SF	4	Sept–Dec 1992
18	Livingstone SF	6+	Sept–Nov 1992
19	Tabletop NR	6	Oct 1992–Oct 1993
20	Benambra SF	6	Sept 1994–Oct 1995
21	Murraguldrie SF	10	Aug 1994–Jan 1996
22	Ellerslie SF	4	Aug–Dec 1995
23	Tumblong SF	4	Aug–Dec 1995
24	Mundarlo Road	4	Aug–Nov 1992
25	Ulandra NR	20+	1992, 1993

Dispersal of the exotic coastal dune plants *Gladiolus gueinzii* and *Trachyandra divaricata* in Australia

Petrus C. Heyligers

Heyligers, P.C. (CSIRO Wildlife and Ecology, GPO Box 284, Canberra ACT 2601) 1999. Dispersal of exotic coastal dune plants Gladiolus gueinzii *and* Trachyandra divaricata *in Australia.* Cunninghamia *6(2): 315–329.*

Gladiolus gueinzii (Iridaceae) and *Trachyandra divaricata* (Liliaceae s.l.) are South African dune plants naturalised in Australia. *Gladiolus gueinzii* has two modes of dispersal: winged seeds, and cormels that may float for up to seven months in seawater. Its Australian occurrences are restricted to New South Wales. It was first collected in 1950 near Newcastle and has spread 250 km to the north and 500 km to the south. From large distances between the early herbarium records it was inferred that buoyancy of the cormels enables *Gladiolus gueinzii* to establish at sites remote from existing populations. The climatic conditions of the area over which *Gladiolus gueinzii* presently occurs are broadly similar to those of the more humid part of its native range. Further spread may be restricted due to unfavourable thermal factors.

Trachyandra divaricata is a 'tumbleweed'. Wind dislodges and carries away the 'crowns' of tangled mature infructescences, in the process peppering their trails with innumerable small seeds. In the 1930s *Trachyandra divaricata* became established near Perth, Western Australia, while in 1940 it was also found near Karridale, 300 km further south. In the intervening area it has become a major weed in the dunes and has spread to paddocks inland, causing poisoning of livestock. *Trachyandra divaricata* has also turned up at several other outlying coastal locations as well as at an inland site. The distances involved are suggestive of dispersal by human agency, for instance through cars or boats. The Mediterranean and adjacent semi-arid climates of the south-west of Western Australia mirror a similar situation in southern Africa. Hence, the area appears to be well suited to *Trachyandra divaricata* and further spread can be expected.

In New South Wales *Trachyandra divaricata* was first found in 1968 at a dune rehabilitation site near Wollongong. It possibly came in as a contaminant of *Acacia saligna* planting stock from Western Australia. Since then it has become established at several other reclaimed areas, but has not spread much beyond such sites, possibly because of unfavourable climatic conditions. Nevertheless, in case aggressiveness takes a turn for the worse, it would appear desirable to eradicate occurrences in New South Wales while this is still achievable.

Introduction

Gladiolus gueinzii Kunze (family Iridaceae) and *Trachyandra divaricata* (Jacq.) Kunze (family Liliaceae s.l.: Asphodelaceae, Anthericaceae) are coastal species native to South Africa. The former occurs in the south-east, the latter in the south-west, with its range

extending along the Namibian coast (Fig. 1). Their distributions overlap along the southern coastline, where *Gladiolus gueinzii* is more common on foredunes with a pioneer vegetation, *Trachyandra divaricata* on older, more densely vegetated dunes. After presumably accidental introduction into Australia, both species have become naturalised and have enlarged their range. In this paper the dispersal ecology and present Australian distribution of *Gladiolus gueinzii* and *Trachyandra divaricata* are analysed and the likelihood of further spread is discussed.

Methods

The data for this paper have been obtained during investigations of the dispersal ecology of strandplants. These investigations started in 1980 and although fieldwork has been predominantly carried out in south-eastern Australia, over the years a good many beaches have been visited elsewhere. Concurrently, experiments were began to test the buoyancy and viability of propagules of various strand- and foredune plants. No great sophistication was applied to these experiments, as there were only two basic questions to be answered: firstly, do propagules float and if so, for how long, and secondly, how long do they remain viable? Seeds, fruits and, in the case of *Gladiolus gueinzii*, cormels were put in jars with seawater and numbers remaining buoyant were regularly assessed. Viability was tested at the start of such experiments, as well as at intervals afterwards. During the earlier years the propagules were sown in a mixture of sand and perlite, but later they were placed on moist filter paper in petri dishes, which were either kept in a growth cabinet or at ambient room conditions. The viability of propagules stored in paper wrappers at, or at somewhat lower than, room temperature was tested as 'control'.

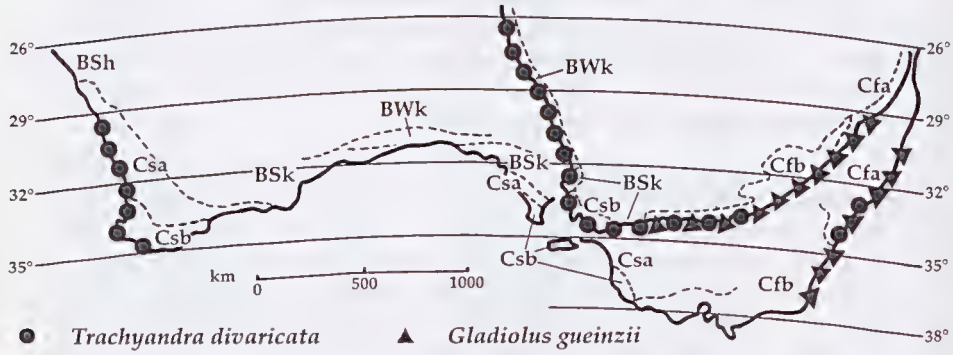

Fig. 1. The geographic distribution of *Gladiolus gueinzii* and *Trachyandra divaricata* in relation to climate. The maps of Africa and Australia south of 26°S have been overlaid for easy comparison of the climates of the coastal regions, which have been classified according to Köppen's scheme (after Schulze & McGee 1978 and Gentilli 1972, respectively). BS: semi-arid, and BW: arid climates with mean annual temperatures above (h) or below 18°C (k); Cs: 'Mediterranean' climates with winter rains and hot, dry summers (a) or long, mild summers (b); Cf: humid mild-winter climates with appreciable rainfall throughout the year, either with hot summers (a), or with mild summers (b).

Collection records for *Gladiolus gueinzii* and *Trachyandra divaricata* were acquired from all major Australian herbaria. These records were used to infer the mode of introduction and subsequent spread, based on the presumptions that the earliest collections would have been made in the general area of where the species first became naturalised and that this area served as the source of further dispersal. Also, if early collections are far apart, but close in time, this would indicate multiple introductions as is, for instance, the case with *Arctotheca populifolia* (Asteraceae; Heyligers 1983, 1998) and *Euphorbia paralias* (Euporbiaceae; Heyligers 1989, 1993). Analysis of the herbarium records of these and other introduced strandline and foredune species with buoyant propagules such as *Cakile edentula, Cakile maritima* (Brassicaceae) and *Hydrocotyle bonariensis* (Apiaceae; Heyligers 1996, 1998), has lead to the hypothesis that the dispersal of such species happens by making 'leaps' entrained in major current systems with subsequent filling in of the 'gaps' by means of largely wind-driven along-shore drift. The records of *Gladiolus gueinzii* provided another opportunity to test this proposition.

Information on occurrence in southern Africa has been exclusively obtained from the literature, especially from taxonomic treatments (Lewis et al. 1972, Obermeyer 1962, Goldblatt & Manning 1998) and from sources found in the comprehensive overview of the coastal vegetation by Lubke et al. (1997).

Nomenclature follows Harden (1990–1993) except for *Cotula turbinata* and *Tetragonia decumbens,* taxa not mentioned in Harden, for which Marchant et al. (1987) was used.

The plants

Gladiolus gueinzii is a small gladiolus with narrow, rather glaucous leaves, which are at best 60 cm long and not uncommonly about half that length (Fig. 2). Hence the plants are rather inconspicuous amongst the similarly grey-green *Spinifex sericeus* (Poaceae) vegetation of the foredunes. Plants grow from corms, which may be located 30 or 40 cm, or even deeper, under the surface. These corms are about 20–30 mm across and somewhat less in height. New corms develop on the top of older ones and thus three generations of corms may be found together, while at their base a mass of dark-brown tunic remnants indicates the demise of previous corms.

Usually, a 'corona' of cormels surrounds the sutures between corms. Cormels develop at the end of short stolons, which grow out from the corm bases (Fig. 2). According to Goldblatt and Manning (1998) cormels produced deep underground have thin, light-brown tunics, while those near the soil surface develop a dark-brown, thick, leathery or corky tunic. In my experience this is a phenomenon that is an expression of ageing rather than of depth under the surface. As cormels are easily dislodged, their number per corm or per plant is not easily assessed, but from a count of stolon remnants and judging from the numbers of cormels found during digging out a clump of plants, 16 cormels per corm, or 35 per plant are likely to be minimum estimates. Cormels may also form in the axils of the sheathing bases of the lower leaves if these nodes are under the surface. Most cormels appear to remain dormant, but some sprout *in situ*, thus forming a clump of plants around the 'parent' (Fig. 2).

The flowering stems are shorter than the leaves and carry one to five, about 3.5 cm long, mauve-pink flowers. The flowers open sequentially, starting with the lowest one, and usually only one flower is open at a time. Their attractively patterned nectar mark remains largely hidden from view, as the flowers hardly open out. Goldblatt and Manning (1998) report that *Gladiolus gueinzii* is self-compatible and autogamous, which is unusual in the genus. The main flowering season is from October till December, when some plants may produce a second generation of flowers on a short branch from the base of the inflorescence or on new stems (Fig. 2). The fruits ripen through the summer and the seeds are shed as soon as the capsules are ripe. The old flowering stems with the dry capsules remain standing for the rest of the year and often during the next season as well, thus providing a more obvious clue to the presence of the species than the living parts of the plants.

In contrast, *Trachyandra divaricata*, False Onion Weed or Strapweed (Hussey et al. 1997) is a conspicuous member of the vegetation. Its lax, narrow, bright-green, rather fleshy leaves spread out over the sand and may be up to one metre long (Fig. 3). Thus, older plants cover considerable areas and are strong competitors for space. They grow from a compact rhizome. To what extent this rhizome can cope with sand burial is not known. It grows upward and outward with stubby 'branches', about 2.0–3.5 cm thick as well as long, and is clothed in many, up to 17 mm long, brown, membranous bracts. Basal sections carry coarse roots covered by a felt-like pubescence of interlacing root hairs, which seem to be able to absorb water very quickly (Obermeyer 1962). In the middle sections roots gradually give way to leaves. Each new rhizome branch produces a -supposedly terminal- inflorescence.

The inflorescences are up to 0.7 m tall and more or less divaricately branched from about halfway. They carry pale-lilac flowers, about 1.5 cm across, which are very attractive to honeybees. Counts have given figures between 100 and 700 flowers per inflorescence. Fruit set is variable. The reasons for this are not immediately apparent; factors such as age of the plants and weather conditions may be implicated. The main flowering season is from mid-winter to late spring, but at least on the east coast of Australia flowering goes through a second season in autumn. There are only a few fruiting stems on a young plant, but older plants carry an impressive 'crown' of infructescences.

Dispersal mechanisms

Both species have adaptations for dispersal by wind and water. The seeds of *Gladiolus gueinzii* are winged, while *Trachyandra divaricata* is a tumbleweed: when ripe and dried-off, the 'crown' of fruiting stems is dislodged and carried away by wind (Fig. 3). In addition, the cormels of *Gladiolus gueinzii* and the dry infructescences of *Trachyandra divaricata* are buoyant in sea water.

The loculicidal capsules of *Gladiolus gueinzii* contain about 40 seeds per capsule. The globular seeds have a diameter of 3 mm and are surrounded by a 4 mm wide wing consisting of 'loose, large cells containing air pockets, which ensures lightness and

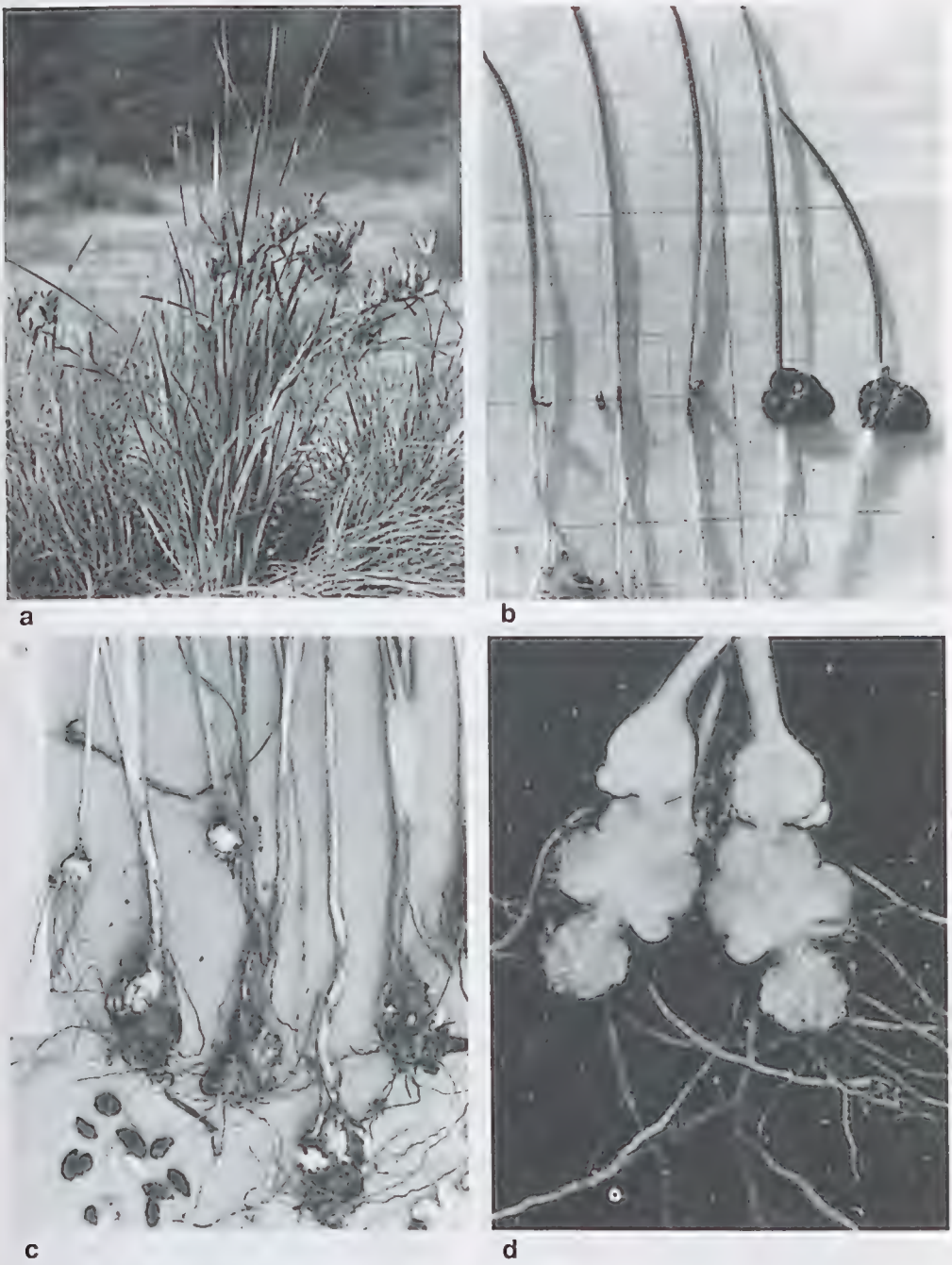

Fig. 2. *Gladiolus gueinzii*. **a**, clump of plants at Nelson Beach, NSW on 24 March 1991; the flowering stems are 40 cm tall; most capsules have shed their seeds; a late-season flowering stem points to the left from the clump centre; **b**, seedlings; the two seedlings at the right are still attached to the winged seed husks (the graph paper has 1 cm main divisions); **c**, underground part of a clump of which the stems have been teased apart showing staggering of corms and cormels which fell off during excavation (the ruler is 20 cm long); **d**, transverse cut through lower part of a stem showing three generations of corms and cormels being formed at the base of the top corm.

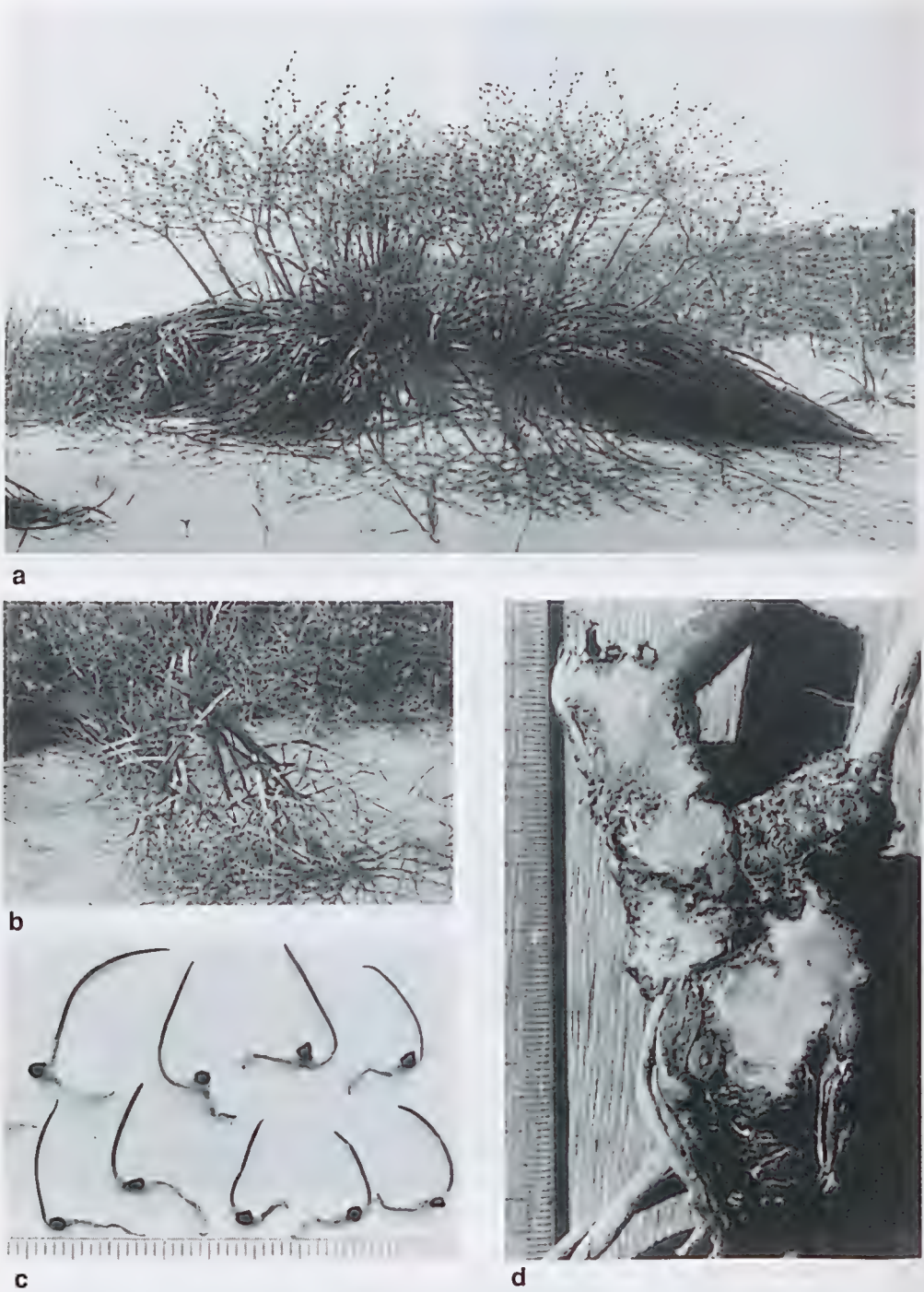

Fig. 3. *Trachyandra divaricata*. **a**, plant with maturing capsules at Coogee Beach, WA on 22 October 1987; **b**, a wind-dispersed 'crown' of infructescences lodged in an open space in *Spinifex longifolius* vegetation at Woodmans Point, WA on 15 September 1988; **c**, seedlings (the ruler divisions are in mm); **d**, transverse cut through part of the branching rhizome showing felt-covered roots and bases of two flowering stems; leaf-scars can be seen on the uncut branch (the ruler divisions are in mm).

wind dispersal' (Lewis et al. 1972; Fig. 2). With commonly only one or a few flowering stems per plant, seed production is in the order of 100 to 400 seeds per plant per year.

In comparison, the much-branched inflorescence of *Trachyandra divaricata* may develop 400 fruits and on average carries about half that number. Each fruit, also a loculicidal capsule, contains from three to 22, on average 11, seeds which are pyramidal in shape and about 2 mm across (Fig. 3). With an average production of about 2000 seeds the reproductive potential of a single infructescence is already an order of magnitude larger than that of a *Gladiolus gueinzii* plant. However, even young *Trachyandra divaricata* plants have a couple of inflorescences and this number increases with age. A clump 0.7 m in diameter may carry about 25 tangled fruiting stems which, dislodged and driven forth by the wind, may pepper their path with 50 000 seeds.

The buoyant cormels of *Gladiolus gueinzii* become vehicles for long-distance dispersal if they are dislodged by wave or wind erosion of foredunes or due to undercutting of sandspits by currents. In South Africa *Gladiolus gueinzii* cormels were found to float for three weeks (Muir 1937). However, in my two tests, each with 30 cormels, 15 stayed afloat for seven or more weeks, while some remained buoyant for longer than half a year (Fig. 4). After 16 months in seawater the cormels were still viable; most sprouted within seven weeks when the fibrous tunics were removed before planting, but it took more than half a year before cormels with intact tunics began to sprout. After 28 months in sea water viability of cormels had greatly declined: only one out of five 'peeled' cormels sprouted after about five months, and none of the cormels with intact tunics. However, five dry-stored cormels sprouted within three weeks when the tunics were removed, while three of the five cormels with intact tunics sprouted later, but within 25 weeks. The corollary of these tests is that cormels washed out to sea can be transported by currents to other beaches and are still capable of sprouting on arrival. Inhibition of sprouting when the tunic has stayed intact may be an advantage if in the meantime the cormel has a greater chance to become covered by sand.

The buoyancy of seeds was also tested. The small unadorned seeds of *Trachyandra divaricata* sank within minutes, but those of *Gladiolus gueinzii*, due to the air trapped in the wings, stayed afloat till the wings had become soaked. Of the 100 seeds tested, none stayed afloat for longer than a week. It would appear that water dispersal of *Gladiolus gueinzii* seed can only be of local significance and hence, it may be merely of theoretical interest that sunken seed remains viable for more than a year.

Dry *Trachyandra divaricata* infructescences are buoyant by virtue of their hollow stems and may stay afloat for several weeks. They sink once they have become waterlogged and the remaining air has been expelled. However, before a bunch of infructescences is blown out to sea, many seeds will already have dropped out, diminishing the colonisation potential of a stranded bunch. When kept in seawater, seeds are still marginally viable after eight months.

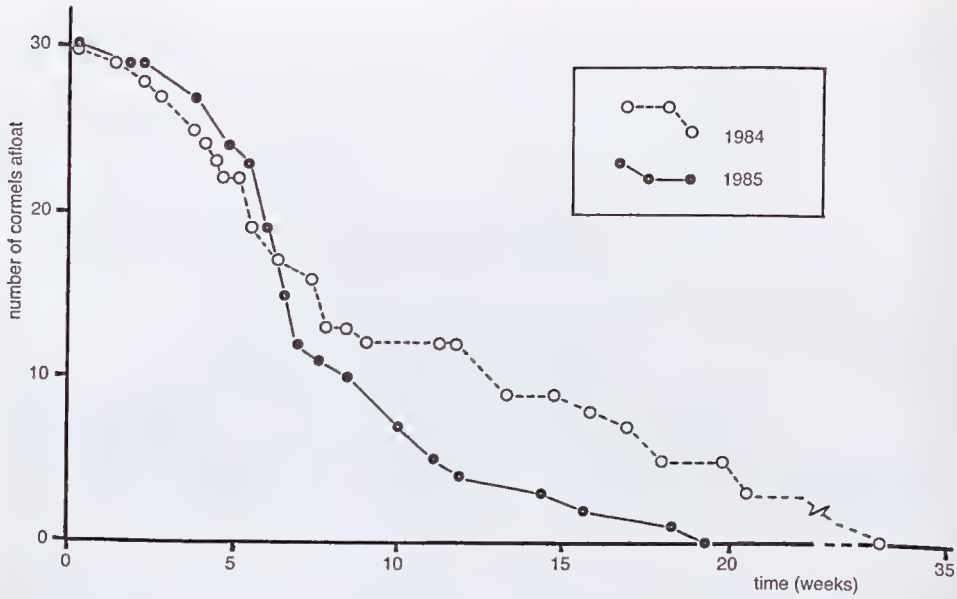

Fig. 4. Buoyancy of *Gladiolus gueinzii* cormels. Results from two tests; the first one was started on 30 September 1984, the second test one year later, each with 30 cormels of the same batch, which was collected on 26 August 1984 near Nowra, NSW. For the tests cormels were put and kept in jars with seawater at ambient room conditions.

A dispersal scenario for *Gladiolus gueinzii*

The Australian occurrences of *Gladiolus gueinzii* are confined to the coast of New South Wales (Fig. 5). The first collection was made in 1950 at Stockton, near Newcastle, a location rich in ballast plants, which include among others *Ursinia chrysanthemoides* and *Cotula turbinata* (Asteraceae), *Tetragonia decumbens* (Aizoaceae) and *Hebenstretia dentata* (Selaginaceae) from South Africa (Heyligers unpubl. obs.). Hence, introduction in dumped ballast appears to be the most likely explanation for *Gladiolus gueinzii*'s arrival on Australian shores. In the 1940s Mort (1949) made an extensive survey of the dune flora of New South Wales with a view to select species suitable for dune rehabilitation. In his enumeration of species he does not mention *Gladiolus gueinzii.* However, he could have missed it as especially non-flowering young plants are easily overlooked in the *Spinifex sericeus* vegetation of the dunes. Nevertheless, it is likely that the 1950 collection date is rather close to the actual date of introduction.

Soon afterwards, in 1953 and 1954, *Gladiolus gueinzii* was also collected at Palm Beach, on the southern peninsula at the entrance to Broken Bay north of Sydney and 90 km south-south-west of Stockton. Unless it was achieved by other means, then this occurrence at Palm Beach is an almost instantaneous demonstration of *Gladiolus gueinzii*'s capacity to disperse by ocean currents. As this species of *Gladiolus* is not available in the nursery trade (it is not listed by Bodkin 1986), and in England is only

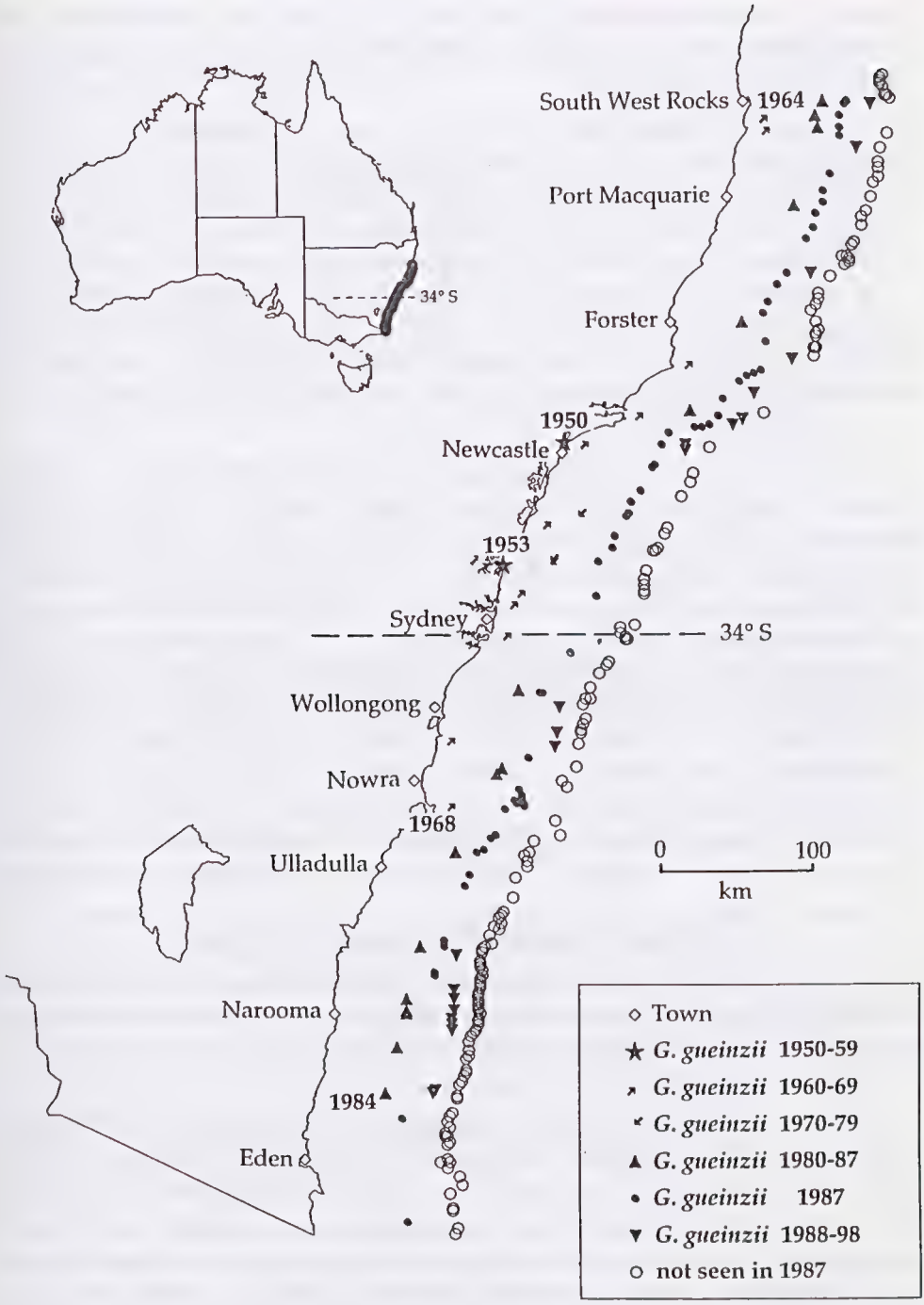

Fig. 5. Collection and observation sites of *Gladiolus gueinzii* in Australia. Sites have been grouped according to periods and these groups have been plotted in rows parallel to the coast. The pre-1980 data refer exclusively to herbarium records, while the 1987 data were gathered by P.J. Clarke during his transect surveys. Dates of collections or observations significant as an indication of the rate of spread have been added to some symbols.

grown by some people with a special interest in this genus (B. Matthews, Royal Botanic Gardens, Kew, pers. comm. 9 October 1987), dispersal by sea would appear to be the most likely explanation.

In 1964 and the following two years *Gladiolus gueinzii* was collected at several sites near South West Rocks, 240 km to the north-northeast of Stockton, while in 1968 at a similar distance in the opposite direction it was collected near Nowra (Fig. 5). In 1984, during my first inspection of Nelson Beach, between Narooma and Eden, I found a well-established population of *Gladiolus gueinzii*, which is another 210 km further south. A detailed transect survey of the vegetation of the coastal dunes in New South Wales in 1987 (Clarke 1989a, b) augments the rather sparse records and showed the widespread occurrence of *Gladiolus gueinzii* along the New South Wales coast south from South West Rocks. However, it is also worth pointing out that there are many dune areas where *Gladiolus gueinzii* is still absent.

The collated information shows that dispersal of *Gladiolus gueinzii* has been an efficient process to which both types of propagules have contributed: cormels in the first instance for dispersal from beach to beach, and seeds as well as cormels for spreading over the dunes backing these beaches. Why there is such an abrupt northern limit to the distribution is not clear. It could be that the local currents under influence of the eddies generated by the East Australian Current run in a counter direction. *Arctotheca populifolia* appears to have come to a dispersal standstill at the same 'barrier'. Hence it will be informative to watch the further northward spread of *Cakile maritima* from its present limit near Port Macquarie (pers. obs. March 1998). On the other hand, *Cakile edentula* and *Hydrocotyle bonariensis* appear to have successfully bypassed this barrier (Heyligers 1998), but it is possible that these species spread southward from southern Queensland, where both had become established by the late 1920s. In a later section the possibility will be discussed, that for *Gladiolus gueinzii* the barrier is a climatic one.

A dispersal scenario for *Trachyandra divaricata*

The first collection of *Trachyandra divaricata* in Australia was made in November 1912 at Coode Island, near Melbourne, a location at the time well-known for its ballast flora (Tovey 1911; Fig. 6). However, it did not persist, nor is there any evidence that it spread to neighbouring areas (Willis 1970).

In the 1930s *Trachyandra divaricata* became naturalised in the south-west of Western Australia. The earliest collection was made in 1932 at Cottesloe, a seaside suburb of Perth and a few kilometres north of Fremantle harbour; the next, in 1938, on the North Mole of that harbour (Fig. 6). Hence, the harbour facilities have most likely been the point of entry. In 1940 *Trachyandra divaricata* was also collected near Karridale, further to the south by about 300 km. As dispersability by currents appears to be limited, the most plausible explanation for bridging this distance in such a short time is that seeds had hitch-hiked on a car or boat, or on clothing or footwear. The role of these particular dispersal agents is often implied but seldom proven. A notable exception is the study by Wace (1977), who analysed the propagules found in the sludge of a car-wash in Canberra. One outcome was that these propagules were usually small and numerous; another, that grassy tumbleweeds were a conspicuous component at certain times of

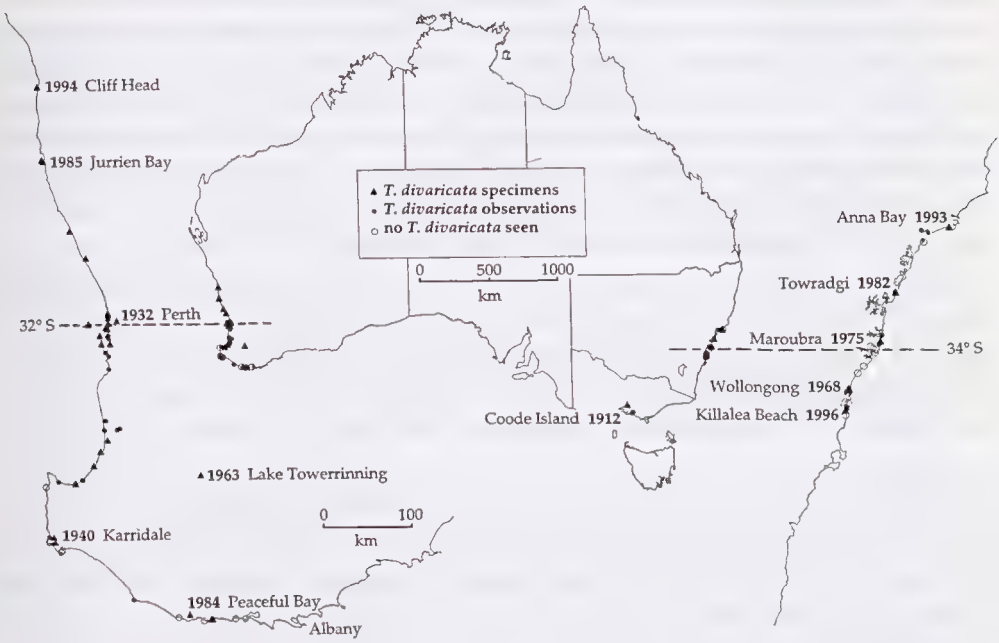

Fig. 6. The distribution of *Trachyandra divaricata* in Australia. The detailed coastline of south-western Western Australia has been centred on the latitude of Perth, that for central New South Wales on the latitude of Sydney. The annotations refer to the earliest dates for herbarium collections from the indicated locations.

the year. Whether the latter result is translatable to *Trachyandra divaricata* should not be too difficult to ascertain.

In the decades following the 1930s *Trachyandra divaricata* spread between Perth and Karridale and has become very common in the dunes. It has also invaded nearby pastoral country, where in times of fodder shortage it is grazed by stock, causing severe and irreversible toxicosis when eaten in quantity over several weeks (Huxtable et al. 1987). If the spread along the coast is mainly due to the 'tumbleweed' action of *Trachyandra divaricata*, a comparison is warranted between the efficiency of this mode of dispersal and that of the primarily sea-dispersed *Gladiolus gueinzii*: in about 50 years the former species 'filled in' a distance of 300 km, while the latter spread from a central focus over a range of 750 km.

In 1963 a collection of *Trachyandra divaricata* was made at Lake Towerrinning, 110 km inland from the coast as the crow flies, but only 25 km west of the nearest approach of the highway between Perth and Albany. In the 1980s *Trachyandra divaricata* was also collected at outlying coastal locations, namely at Jurien Bay, 200 km to the north of Perth, and at Peaceful Bay, 350 km south-south-east of Perth. During fieldwork in November 1988 I found it to be well established in the latter area, not just occurring in the foredunes, but also densely along some roads and vehicular tracks and scattered in the camping ground, where notwithstanding regular mowing it was coming into flower. The only other location along the coast between Albany and Karridale where I

found *Trachyandra divaricata* was at Windy Harbour, 85 km west of Peaceful Bay, where a couple of plants were seen near the jetty. My presumption is that its journey to all these locations has been human-assisted. Jurien Bay is a fishing settlement, while the southern coastal locations are holiday destinations. Unless the situation during the intervening decade has rapidly changed, Hussey et al.'s (1997) statement that *Trachyandra divaricata* 'is widespread through the lower south-west from Jurien Bay to Albany, especially in interdunal beach heathland and roadsides on calcareous sandy soils' appears to be an overstatement of its present distribution.

Trachyandra divaricata has also been found on some of the smaller islands south-west of Perth: Carnac Island, Seal Island, Penguin Island and an unnamed island between the last two (Abbott & Black 1980). Although these islands do receive human visitation, given that the windblown infructescences may float for some weeks, it is also possible that *Trachyandra divaricata* arrived there as a component of flotsam.

Along the east coast of Australia *Trachyandra divaricata* was collected in 1968 at Fairy Meadow, north of Wollongong (Fig. 6). Since then it has been collected at, or reported from, several other locations along the Central Coast of New South Wales with Anna Bay, north-west of Newcastle, as the furthest location in northern direction and Killalea Beach, 30 km south of Wollongong, the furthest south. At most if not all of these sites dune restoration work has been carried out, often including planting of *Acacia saligna*, a species endemic to Western Australia. Therefore, it is likely that *Trachyandra divaricata* arrived as a contaminant of *Acacia saligna* seed or planting stock. Although some substantial populations have become established in the vicinity of these restoration sites, the 1987 dune vegetation survey of New South Wales (Clarke 1989a, b) has not come across occurrences elsewhere.

The likelihood of further spread

The climates of the coastal regions of southern Australia and southern Africa have a great deal in common (Fig. 1). Of the various climate classifications available, that of Köppen has been used, but other classifications, for instance the one devised by Walter and Leith (1967), would have given a similar pattern.

In southern Africa, *Gladiolus gueinzii* occurs from the humid warm climates with mild winters (Cfa, Cfb) in the south-east to the semi-arid conditions prevailing towards the western end of its range (BSk). In Australia, *Gladiolus gueinzii* is at this stage restricted to shores with Cfa and Cfb regimes which however have a less pronounced seasonal difference in rainfall than is the case in South Africa, where rainfall in winter is lower than in summer. Although it would appear from a comparison of the maps that there is no climatic barrier to *Gladiolus gueinzii* extending its range in New South Wales, the lesser seasonality of the rainfall may cause conditions to be unsuitable. Another possibility is that in both directions successful establishment is prevented by a temperature factor, especially in the south, where on average winter temperatures fall outside those experienced along the southern coastline of Africa. If that is the case, then *Gladiolus gueinzii* has about reached its limits in south-eastern Australia. However, an introduction into the more seasonal and drier areas along the southern coast of the continent could provide an opportunity for further colonisation.

Trachyandra divaricata occurs along the coasts of the south-western corner of the African continent (Fig. 1). It is a common and widespread dune plant in the Cape Town region, which has a Mediterranean climate (Csb), and the adjacent coasts, which are semi-arid (BSk). To the north *Trachyandra divaricata* is found also in the arid region of the Namib (BWk). Along the southern coast its distribution extends into the area with a marginal Cfb climate (mapped by Walter & Leith (1967) as transitional between Csb and Cfb). It reaches its eastern limit where summer rainfall markedly increases. In the south-western tip of Western Australia *Trachyandra divaricata* has found a close match with the climate prevailing in the Cape Town region, although winter rainfall is somewhat higher. The Mediterranean climate (Csa, Csb) extends along the coast northward as well as eastward, eventually giving way to much drier climates (BSh, BSk). Hence, climate-wise, there appears to be no impediment for *Trachyandra divaricata* to considerably enlarge its distribution in this corner of the continent.

In contrast to south-western West Australia, the Central Coast of New South Wales receives on average ample rain all year round. As this type of climate lies outside any regime that *Trachyandra divaricata* is subjected to in its native range, it is possible that this at least partly explains why in the more than 35 years since *Trachyandra divaricata* was first reported, it has not aggressively spread. Nevertheless, in case aggressiveness takes a turn for the worse, it would appear desirable to eradicate occurrences in New South Wales while this is still achievable.

Wetter and cooler conditions could also have contributed to the fact that *Trachyandra divaricata* did not spread from Coode Island. But as the island is a busy harbour facility, it is just as likely *Trachyandra divaricata* disappeared due to quite different causes.

Conclusion

I have outlined possible scenarios for the spread of *Gladiolus gueinzii* and *Trachyandra divaricata* along sections of the coast of southern Australia. The data for this were obtained from herbarium records and augmented with other information on location-specific occurrences. Both species are wind-dispersed, although the capacity of *Trachyandra divaricata* for this mode of dispersal is far superior to that of *Gladiolus gueinzii*. The reason for this is not only a much larger seed production, but also the fact that the entangled ripe infructescences function as tumbleweeds. However, to explain various disjointed occurrences satisfactorily, human-mediated transport was suggested to be another important factor in the spread of this species.

Gladiolus gueinzii forms cormels, which can stay afloat for many months if they have been washed out to sea. This provides a means for long-distance dispersal and appears to have been the main agent for its relatively rapid spread along the coast of New South Wales. The buoyancy of *Trachyandra divaricata* infructescences lasts at best for only a couple of weeks and as many seeds will have dropped out before the sea is reached, this mode of dispersal is presumed to be of only minor importance in this species.

At some stage each species was introduced at locations with climatic conditions favourable for their colonisation. *Gladiolus gueinzii* has so far remained within its 'natural' range and further spread may be curbed by conditions either too hot or too cold for its survival, but *Trachyandra divaricata* is likely to enlarge its range as there appear to be no climatic barriers to prevent this from happening. In contrast, where it has been found outside its 'natural' climatic bounds, it has either disappeared or only spread to a limited extent, which was, probably more often than not, solely due to fortuitous human assistance.

Acknowledgements

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Vegetation and floristics of the Demon Nature Reserve, Tenterfield, New South Wales

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A floristic survey of 40 × 0.1 ha plots within the Demon Nature Reserve, 30 km east-south-east (lat. 29°05'S, long 152°15'E) of Tenterfield, was conducted in March, 1997. The Reserve (887 hectares in area) is on a western facing escarpment ranging from 500–1000 m above sea level. The survey data were analysed and seven vegetation communities defined. This paper describes the seven communities and discusses their significance and distribution within the reserve. A vegetation map and plant species list are provided.

Introduction

The Demon Nature Reserve is located approximately 30 km ESE of Tenterfield (lat 29°05'S, long 152°15'E) on the Timbarra Plateau, between Demon Creek and Poverty Point Fire Trail, within the Tenterfield Local Government Area on the Northern Tablelands of New South Wales. It was designated on 22 December 1995, prior to which it formed part of the Malara State Forest in the Tenterfield Management District and a small section was a Camping Reserve for traveling stock managed by the Rural Lands Protection Board. While under the management of the NSW State Forests, the area was used for winter grazing and burnt on a regular three to five year cycle. Parts of the Reserve, particularly above 900 m altitude, were logged between 1980 and 1989 (State Forests of NSW 1995).

The Reserve (887 ha in area), is located on granites of the New England Batholith, and features plateau and escarpment areas with steep ridges and gullies and westerly flowing streams. Elevation ranges from 460 to 1060 m and is lowest at the western boundary and highest in the east. The vegetation consists predominantly of open forest, woodland and rainforest. In addition, heathland is present on outcrops and sedgeland occurs in low-lying areas and depressions.

Previous flora survey work has been carried out in the vicinity of the reserve particularly by the State Forests of NSW (Binns 1995), and also by Capricornia Prospecting (1995) for an environmental impact statement on a proposed gold mine. Only one previous vegetation survey plot had been located within the reserve itself.

This paper represents part of the results from a flora survey conducted on behalf of the Glen Innes District National Parks and Wildlife Service to assist in the development of appropriate management strategies for the nature reserve (ERM Mitchell-McCotter 1998).

Climate

The climate of the Timbarra Plateau is cool-temperate, with cold winters and mild summers. The rainfall maximum is in summer (46% of the total rainfall), with a mean annual fall of c. 1000 mm. Light snow falls are known to occur in some years between May and October at the higher elevations (State Forests of New South Wales 1995). At Tenterfield the mean maximum and minimum temperatures in July are 1°C and 14°C respectively and are 13°C and 26°C in December (RACAC 1996). Winds are mainly north-easterly to easterly between October and May and south-westerly between June and September (State Forests of NSW 1995).

Geology and soils

The geology of the Timbarra Plateau is a composite of the later Permian to Early Triassic Stanthorpe and Bungulla Adamellites (Capricornia Prospecting 1995). Stanthorpe Adamellite occurs throughout the reserve (State Forests of New South Wales 1995). A small portion of microgranite occurs in the south-eastern portion of the reserve (pers. obs. J.T.H.) and also a minor occurrence of Quaternary alluvium deposits with subsequent peat formation. The western boundary of the reserve is marked by the Demon Fault which extends north and south from approximately Tenterfield to Ebor.

Methods

After aerial photographs, geological and topographic maps were consulted a stratified random sampling method was used in order to locate floristic survey sites. Forty allocated sites were surveyed using nested quadrats. For replication purposes the reserve was divided into three approximately equal sections and these were stratified into four elevation classes (200 m bands) and three aspect classes (North, West and South). In addition, special communities that are often missed in stratified sampling due to their minor and restricted occurrences were also targeted (rock outcrops and wetlands). Due to the rugged terrain of steep cliffs and gullies, not all areas were thoroughly surveyed.

The nested quadrat design was described by Bunce and Shaw (1973) and initially tested by Outhred (1984). This method is based on a series of smaller (nested) quadrats that decrease in size geometrically within a larger quadrat. Studies by Outhred (1984), Outhred et al. (1985), Le Brocque and Buckney (1995), Morrison, Cary et al. (1995), and Morrison, Le Brocque et al. (1995) have shown this method capable of detecting subtle community patterns by being functionally equivalent to frequency and directly related to plant density. The method was modified to enable approximately 0.1 ha to be surveyed and a frequency score of ten to be given to each taxon found. Each quadrat was marked out by the placement of four 30 m measuring tapes marking the diagonals. Markings were placed on the measuring tapes at distances from the centre of the quadrat at 1, 1.4, 2, 2.8, 4, 5.7, 8, 11.2, 16 and 22.5 m. This divided the total quadrat into nine sub-quadrats of approximate cumulative area; 2, 4, 8, 16, 32, 64, 128, 256, 512, 1024 m^2. All vascular plant species were recorded for each quadrat. The

presence or absence of a taxon in each of the nine subquadrats gave a frequency score out of ten for each taxon, providing a measure of relative abundance. This same alteration in design has been used by Clarke et al. (1995), Clarke et. al. (1998) and Hunter and Clarke (1998) for vegetation surveys in north-east NSW. Where topographic features were linear in nature (e.g. creeks) a linear version of this method was used which did not compromise the sampling design. This was achieved by extending the last two subquadrats on one side (retaining the same area), thereby creating a rectangular plot.

The survey was carried out over three weeks during March 1997. A total of 320 voucher specimens were collected, and these are held by the Glen Innes District of the National Parks and Wildlife Service. Duplicate material was incorporated within the NCW Beadle Herbarium of the University of New England, Armidale (NE). Nomenclature follows Harden (1990–1993) except where subsequent relevant changes have been made.

Analyses and data exploration were performed using options available in the PATN Analysis Package (Belbin 1995a, b). For final presentation of results all species and their relative abundance scores were used and the analysis was performed using the Kulczynski association measure which is recommended for ecological applications (Belbin 1995a, b) along with flexible UPGMA and the default PATN settings.

Vegetation mapping was prepared as part of the survey and is based on the PATN analysis results presented here. Delineation of community boundaries was based on the location of sites and their position within the multivariate analysis and on subsequent air photo interpretation and ground truthing.

Results

A total of 365 taxa were recorded from 95 families during the survey of the Demon Nature Reserve (Appendix). Seven communities were distinguished within the reserve at a dissimilarity measure of c. 0.75 (Figs. 1 & 2).

A number of nationally rare or threatened taxa were discovered within the reserve. These included: *Acacia floydii* (2RC-), *Acacia orites* (2RC-), *Acianthus exiguus* (3RC-) (Schedule 2 Vulnerable Species under the TSC Act 1995), *Eucalyptus dorrigoensis* (3KC-), *Prostanthera* sp. B (2RC-) (Briggs & Leigh 1996), *Eucalyptus scias* subsp. *apoda* (3V-) (Quinn et al. 1995), and *Philotheca myoporoides* subsp. *epilosus* (3RCa) (Richards & Hunter 1997). Additionally, infertile specimens of some taxa are of potential interest, particularly a specimen with affinities to *Pomaderris notata* (2RC-t), and a *Pultenaea* sp. aff. *obovata* specimen that does not conform to a recognised taxon.

Few exotic taxa were noted within the reserve and most of these were taxa that are generally ubiquitous to the region and often occur in undisturbed communities. The most common and abundant of these was *Hypochaeris radicata*. Other taxa include: *Gomphocarpus physocarpus, Conyza albida, Gnaphalium americanum, Bidens pilosa* and *Centaurium erythraea*.

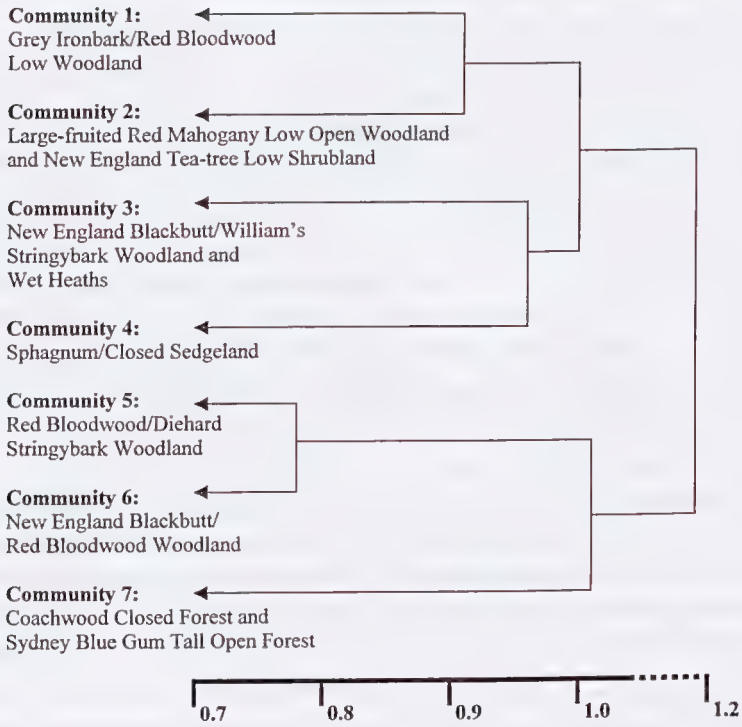

Fig. 1. Summary dendrogram of the communites defined within Demon Nature Reserve produced by the Kulczynski association measure.

Plant communities

The taxa in each community are listed below according to their importance, which has been based on the number of quadrats in which they occurred (fidelity) and their total summed frequency score (relative abundance).

Community 1: Grey Ironbark–Red Bloodwood Low Woodland (*Eucalyptus fusiformis–Corymbia gummifera*)

Trees: *Eucalyptus fusiformis, Corymbia gummifera, Eucalyptus propinqua, Lophostemon confertus.*
Shrubs: *Acacia diphylla, Melichrus urceolatus, Hibbertia obtusifolia, Phyllanthus gunnii, Mirbelia pungens.*
Herbs: *Pomax umbellata, Cymbopogon refractus, Aristida jerichoensis, Opercularia hispida, Trachymene incisa, Entolasia stricta, Vernonia cinerea, Restio stenocoleus, Cheilanthes sieberi* subsp. *sieberi, Gahnia aspera.*
Notes: This community occurs at lower altitudes and has a distinct understorey of *Acacia* that often forms dense stands along the Demon Fault. (116 taxa).

Fig. 2. Vegetation map of Demon Nature Reserve. Coachwood Closed Forest–Sydney Blue Gum Tall Open Forest (heavy stippling); Grey Iron bark–Red Bloodwood Low Woodland (horizontal bars); Large-fruited Red Mahogany Low Open Woodland & New England Tea-tree Low Shrubland (black); New England Blackbutt–William's Stringybark Woodland (diagonal bars) and Wet Heaths (vertical bars); Sedgeland (hatching); Red Bloodwood–Diehard Stringybark Woodland (light stippling); New England Blackbutt–Red Bloodwood Woodland (clear). Elevation bars are in 100 m intervals (500–1000 m). Scale bar = 2 km.

Community 2: Large-fruited Red Mahogany Low Open Woodland and New England Tea-tree Low Shrubland (*Eucalyptus scias* subsp. *apoda–Allocasuarina littoralis*)

Trees: *Eucalyptus scias* subsp. *apoda, Allocasuarina littoralis.*
Shrubs: *Acrotriche aggregata, Leucopogon lanceolatus, Acacia floydii, Leptospermum novae-angliae, Leptospermum polygalifolium* subsp. *transmontanum.*
Herbs: *Entolasia stricta, Trachymene incisa, Brachyscome stuartii, Lomandra longifolia, Gonocarpus teucrioides, Pomax umbellata, Dianella caerulea, Stylidium laricifolium, Themeda triandra, Laxmannia compacta.*
Notes: This community is scattered throughout the upper altitudes along the escarpment on granitic outcrops. Several restricted taxa occur and include: *Eucalyptus scias* subsp. *apoda, Acacia floydii, Prostanthera* sp. B, *Philotheca myoporoides* subsp. *epilosus.* (114 taxa).

Community 3: New England Blackbutt–William's Stringybark Shrubby Woodland and Wet Closed Heaths (*Eucalyptus campanulata–Eucalyptus williamsiana–Eucalyptus cameronii*)

Trees: *Allocasuarina littoralis, Eucalyptus campanulata, Eucalyptus williamsiana, Eucalyptus cameronii, Eucalyptus dorrigoensis.*
Shrubs: *Dampiera stricta, Dillwynia phylicoides, Petrophile canescens, Pimelea linifolia, Leptospermum trinervium, Monotoca scoparia, Persoonia oleoides, Acacia ulicifolia, Daviesia villifera, Melichrus procumbens.*
Herbs: *Stylidium graminifolium, Platysace ericoides, Entolasia stricta, Austrostipa pubescens, Amperea xiphoclada, Pteridium esculentum, Goodenia bellidifolia, Patersonia glabrata, Patersonia sericea, Lepidosperma gunnii.*
Notes: A small occurrence of this community can be found on the plateau at the southern end of the reserve. The community includes two major sub-communities: wets heaths and logged woodlands. The restricted species *Eucalyptus dorrigoensis* was found along a creek margin within this community. (72 taxa).

Community 4: Sphagnum–Sedgeland (*Lepidosperma limicolum–Baeckea omissa*)

Shrubs: *Baeckea omissa, Epacris obtusifolia, Callistemon citrinus, Epacris microphylla, Leptospermum brachyandrum.*
Herbs: *Lepidosperma limicolum, Caustis flexuosa, Drosera binata, Thelionema caespitosa, Schoenus brevifolius.*
Notes: This was the most restricted community within the reserve occupying only 0.1 ha. (35 taxa).

Community 5: Red Bloodwood–Diehard Stringybark Woodland (*Corymbia gummifera–Eucalyptus cameronii*)

Trees: *Corymbia gummifera, Eucalyptus cameronii, Allocasuarina torulosa, Eucalyptus campanulata, Angophora floribunda.*
Shrubs: *Podolobium ilicifolium, Melichrus urceolatus, Persoonia sericea, Hibbertia obtusifolia, Acrotriche aggregata.*

Herbs: *Dianella caerulea, Pomax umbellata, Lepidosperma laterale, Lomandra confertifolia, Desmodium varians, Dichelachne rara, Themeda triandra, Imperata cylindrica, Vernonia cinerea, Lomandra multiflora.*
Notes: This community is common throughout intermediate altitudes. Restricted taxa include *Acacia floydii, Eucalyptus scias* subsp. *apoda* and *Acacia orites*. (131 taxa).

Community 6: New England Blackbutt–Red Bloodwood Woodland (*Eucalyptus campanulata–Corymbia gummifera*)

Trees: *Banksia integrifolia, Eucalyptus campanulata, Allocasuarina littoralis, Corymbia gummifera, Allocasuarina torulosa, Eucalyptus scias* subsp. *apoda, Eucalyptus oreades, Eucalyptus cameronii.*
Shrubs: *Hibbertia obtusifolia, Leucopogon lanceolatus, Acacia falciformis, Persoonia oleoides.*
Herbs: *Viola betonicifolia, Lomandra longifolia, Platysace ericoides, Imperata cylindrica, Glycine microphylla, Geranium solanderi, Gonocarpus teucrioides, Dianella caerulea, Desmodium varians.*
Notes: This community is widespread throughout the plateau and upper parts of the escarpment. The restricted species *Eucalyptus dunnii, Eucalyptus scias* subsp. *apoda, Acacia floydii* and *Acianthus exiguus* occur here. (170 taxa).

Community 7: Coachwood Closed Forest and Sydney Blue Gum Tall Open Forest (*Callicoma serratifolia–Ceratopetalum apetalum*)

Trees: *Allocasuarina torulosa, Callicoma serratifolia, Backhousia myrtifolia, Ceratopetalum apetalum, Quintinia sieberi.*
Shrubs: *Trochocarpa laurina, Senecio amygdalifolius, Acacia floydii, Alyxia ruscifolia, Notelaea* sp. *A.*
Vines: *Cephalaralia cephalobotrys, Eustrephus latifolius, Parsonsia straminea, Rubus parvifolius, Cissus hypoglauca.*
Herbs: *Blechnum cartilagineum, Lomandra longifolia, Desmodium varians, Doodia aspera, Hypolepis glandulifera.*
Notes: This community is common in the gullies and on south facing protected slopes. Two sub-communities can be distinguished here, namely a Closed Forest component and the surrounding Tall Open Forest with a closed forest emergent canopy underneath. Often the Tall Open Forest is narrow and is usually dominated by *Lophostemon confertus* and *Eucalyptus saligna*. Restricted species include *Acacia orites, Acacia floydii* and *Eucalyptus scias* subsp. *apoda*. (134 taxa).

Discussion

Topography and disturbance history have been important in determining the distribution of communities within Demon Nature Reserve. Community 7 was restricted to deeply incised gullies that were protected from western exposure and the regular fires that have occurred. This community is depauperate in comparison to other Closed Forests described for the Timbarra Plateau (Capricornia Prospecting

1995, Binns 1995) but is typical in its floristic assemblage. Floyd (1990) describes similar associations within the *Ceratopetalum* Alliance in warm-temperate rainforest. These associations are distributed throughout north-eastern New South Wales. Community 7 has the potential for expansion if fires become less regular, particularly within gullies and along creeklines on the plateau area of the reserve.

The three most widespread communities within the reserve were all of woodland formation. These communities were banded topographically. Community 1 occurred at the lowest altitudes, being replaced at mid altitudes by Community 5, which was then replaced on the escarpment edge and plateau areas by Community 6. Community 6 was the most disturbed community within the reserve with recent forest harvesting, regular low intensity fires and grazing. A noticeable feature of Community 1 was a very dense understorey of *Acacia* which coincided with the trace of the Demon Fault. This was readily discernible on aerial photographs and viewing points that overlooked the reserve. At present, we have no explanation for this. Locally, Communities 1, 5 and 6 are widespread throughout the escarpment and plateau areas of the whole Timbarra Plateau (Capricornia Prospecting 1995). Only a small portion of Community 3 was found within the reserve, however, it appears to be widespread throughout the plateau.

In the analysis a number of restricted and specialised communities were defined. Community 4 was restricted to a very small area of impeded drainage on the plateau and was within 50 m of the only access road, thus representing the most restricted and potentially vulnerable community within the reserve. Communities containing sphagnum are highly restricted on the Northern Tablelands, occurring only at higher altitudes with mean annual rainfalls between 1000–1300 mm (Beadle 1981). Similar communities are known to occur within Boonoo Boonoo, Bald Rock, Gibraltar Range, New England and Cathedral Rock National Parks and the Serpentine Nature Reserve on the Northern Tablelands. Community 2 was restricted to small rock outcrops within the reserve. It is depauperate in species and diversity in comparison to other more complex communities found on the Timbarra Plateau, particularly in the east. Binns (1995) and Hunter & Clarke (1998) describe granitic outcrop communities for the region. Community 3a and 4a of Hunter & Clarke (1998) are directly synonymous with Community 2. Unlike most rock outcrop communities on the eastern escarpment of the Northern Tablelands, Community 2 is more open in structure, being a shrubland rather than closed heath. Community 2 is devoid of some of the more common components usually found in rock outcrop communities on the eastern escarpment such as *Kunzea bracteolata* or *Leptospermum novae-angliae*, which are largely absent here.

Restricted taxa

A number of nationally rare and or threatened taxa were found within the reserve. *Acacia floydii*, *A. orites* and *Eucalyptus scias* subsp. *apoda* were present in large numbers throughout most of the reserve. Of particular note is *Eucalyptus scias* subsp. *apoda*, as this represents the only known occurrence in a conservation reserve. Johnson & Hill (1990) when describing this taxon indicated that it was usually confined to swampy sites, however we found this taxon was most common on shallow, well drained soils,

on and surrounding, granitic outcrops. The recording of *Philotheca myoporoides* subsp. *epilosus* within the reserve confirms the decision of Richards and Hunter (1997) to downgrade the coding of this species to 3RCa. Two taxa of particular note are the two varieties of *Lasiopetalum ferrugineum* which both occur within the reserve. The finding of *Lasiopetalum ferrugineum* var. *cordatum* is an additional record of this taxon to those found in Butterleaf National Park for the Northern Tablelands (Richards & Hunter 1997) and the record of *Lasiopetalum ferrugineum* var. *ferrugineum* represents the first recording of this variety for the Northern Tablelands. *Acianthus exiguus* is the only species currently listed on the *Threatened Species Conservation Act* (New South Wales Government 1995).

Conclusion

Although small, the Demon Nature Reserve has a number of communities that are representative of those found throughout the Timbarra Plateau. Some of these are also representative of far more widespread communities typical of the eastern portion of the Northern Tablelands and the associated escarpment areas. Other communities such as those found on rock outcrops, or on impeded drainage, are very small and depauperate compared to what is known for the Timbarra Plateau or the region in general. It is likely that sampling at other times of the year will yield further records, additionally some of the more inaccessible areas of the reserve that were not sampled intensively. Due to past management history and the subsequent change in management strategies (for example no further selective logging, a reduced fire regime, and exclusion of grazing), it is likely that the extent, and in some instances the composition of the seven communities described here will change.

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Appendix: List of vascular plant taxa recorded from the Demon Nature Reserve with recognised authorities for taxa with new nomenclature since Harden (1990–1993). Taxa are scored according to their occurrence in each of the seven flexible UPGMA communities defined.
*** denotes introduced species.**

	C1	C2	C3	C4	C5	C6	C7
PTERIDOPHYTES AND ALLIES							
Adiantaceae							
Adiantum aethiopicum							X
Adiantum hispidulum						X	X
Aspleniaceae							
Asplenium australasicum							X
Asplenium flavellifolium		X			X	X	X
Blechnaceae							
Blechnum cartilagineum						X	X
Blechnum wattsii							X
Doodia aspera							X
Davalliaceae							
Davallia pyxidata					X	X	
Dennstaedtiaceae							
Dennstaedtia davallioides							X
Hypolepis glandulifera					X	X	X
Pteridium esculentum		X	X	X	X	X	X
Gleicheniaceae							
Gleichenia dicarpa							X
Sticherus lobatus							X
Lindsaeaceae							
Lindsaea linearis			X		X	X	
Lindsaea microphylla							X
Lycopodiaceae							
Lycopodium laterale				X			
Osmundaceae							
Todea barbara							X
Polypodiaceae							
Dictymia brownii							X
Grammitis billardieri							X
Microsorum postulatum							X
Platycerium bifurcatum subsp. *bifurcatum*				X		X	X
Pyrrosia confluens		X			X	X	X
Pyrrosia rupestris		X					X
Schizaeaceae							
Schizaea bifida		X					
Selaginellaceae							
Selaginella uliginosa			X	X			
Sinopteridaceae							
Cheilanthes distans	X						
Cheilanthes sieberi subsp. *sieberi*	X	X			X	X	
Pellaea falcata var. *nana*	X						X

	C1	C2	C3	C4	C5	C6	C7
MONOCOTYLEDONS							
Anthericaceae							
Arthropodium milleflorum	X				X	X	
Laxmannia compacta		X					
Thysanotus tuberosus subsp. *tuberosus*		X	X		X	X	X
Tricoryne anceps subsp. *erocaulon*	X						
Araceae							
Gymnostachys anceps						X	X
Asteliaceae							
Cordyline petiolaris							X
Commelinaceae							
Commelina cyanea	X	X			X	X	
Cyperaceae							
Bulbostylis densa		X					
Caustis flexuosa				X			
Cyperus imbecillis	X					X	
Cyperus lhotskyanus	X						
Fimbristylis dichotoma	X	X			X	X	
Gahnia aspera	X				X		X
Gahnia sieberiana						X	X
Gymnoschoenus sphaerocephalus							X
Lepidosperma gunnii			X				
Lepidosperma laterale	X	X	X		X	X	X
Lepidosperma limicolum			X	X			
Lepidosperma tortuosum			X	X	X		
Schoenus apogon		X				X	
Schoenus brevifolius		X	X	X		X	
Schoenus melanostachys	X		X				
Scleria mackaviensis	X						
Tricostularia pauciflora				X			
Haemodoraceae							
Haemodorum planifolium	X		X		X	X	
Hypoxidaceae							
Hypoxis exilis						X	
Iridaceae							
Patersonia fragilis				X			
Patersonia glabrata		X	X		X	X	
Patersonia sericea						X	
Juncaceae							
Juncus remotiflorus						X	
Lomandraceae							
Lomandra confertifolia subsp. *rubiginosa*	X	X			X	X	X
Lomandra filiformis subsp. *filiformis*	X		X		X	X	
Lomandra longifolia	X	X			X	X	X
Lomandra multiflora	X		X		X	X	X
Luzuriagaceae							
Eustrephus latifolius	X	X			X	X	X

	C1	C2	C3	C4	C5	C6	C7
Orchidaceae							
Acianthus apprimus	X	X	X		X	X	X
Acianthus exiguus						X	
Bulbophyllum bracteatum		X					
Bulbophyllum elisae		X		X			
Bulbophyllum exiguum							X
Chiloglottis diphylla			X				
Chiloglottis sp.		X		X	X	X	
Cryptostylis subulata		X	X				X
Dendrobium kingianum		X			X		X
Dendrobium speciosum		X					X
Dipodium variegatum						X	
Eriochilus cucullatus						X	
Prasophyllum patens						X	
Pterostylis decurva							X
Pterostylis longifolia			X		X		
Pterostylis reflexa					X	X	
Spiranthes sinensis var. *australis*				X			
Thelymitra sp.			X			X	
Phormiaceae							
Dianella caerulea var. *assera*		X				X	X
Dianella caerulea var. *caerulea*	X	X	X		X	X	
Stypandra glauca		X					
Thelionema caespitosum				X			
Poaceae							
Aristida jerichoensis var. *subspinulifera*	X	X	X		X		
Austrodanthonia induta (Vickery) H.P. Linder			X	X			
Austrodanthonia tenuior (Steud.) H.P. Linder					X		
Austrostipa pubescens (R.Br.) S.W.L.Jacobs & J.Everett		X	X	X	X	X	X
Cymbopogon refractus	X				X	X	
Dichelachne rara	X	X	X		X	X	
Deyeuxia gunniana				X	X	X	X
Deyeuxia mckiei	X					X	X
Digitaria breviglumis	X	X			X	X	
Digitaria longiflora	X	X					
Echinopogon ovatus	X	X			X	X	X
Entolasia marginata	X						
Entolasia stricta	X	X	X		X	X	X
Eragrostis elongata	X	X		X	X		
Imperata cylindrica	X	X			X	X	X
Microlaena stipoides var. *stipoides*	X				X	X	
Oplismenus aemulus	X				X	X	X
Oplismenus imbecillis	X						
Panicum simile	X					X	
Paspalidium constrictum	X						
Poa sieberiana	X	X	X		X	X	X
Sorghum leiocladum					X		
Themeda australis	X	X			X	X	
Thonandia longifolia (R.Br.) P. Linder	X						
Tripogon loliiformis	X	X					

	C1	C2	C3	C4	C5	C6	C7
Restionaceae							
Baloskion stenocoleum (L.A. Johnson & O.D. Evans) B.G. Briggs & L.A.S. Johnson	X		X	X			
Lepyrodia scariosa			X	X			
Smilacaceae							
Smilax australis			X		X	X	X
Smilax glyciphylla		X				X	X
Xanthorrhoeaceae							
Xanthorrhoea johnsonii			X			X	
Xanthorrhoea malacophylla							X
Xanthorrhoea media						X	
Xyridaceae							
Xyris operculata				X			
DICOTYLEDONS							
Apiaceae							
Hydrocotyle geraniifolia	X	X	X	X	X	X	
Platysace ericoides		X	X		X	X	
Trachymene incisa		X				X	
Apocynaceae							
Alyxia ruscifolia							X
Parsonsia straminea	X					X	X
Araliaceae							
Cephalaralia cephalobotrys							X
Polyscias sambucifolius						X	X
Asclepiadaceae							
**Gomphocarpus physocarpus*							X
Asteraceae							
**Bidens pilosa*	X						
Brachyscome microcarpa	X			X			
Brachyscome stuartii		X				X	
Bracteantha bracteatum						X	X
Cassinia aculeata		X					
Chrysocephalum apiculatum	X				X		
Chrysocephalum semipapposum						X	
Craspedia canens						X	
Conyza albida	X				X	X	
Glossogyne tannensis	X						
Gnaphalium americanum	X	X				X	X
Helichrysum boormanii		X				X	
Helichrysum scorpioides					X	X	
**Hypochaeris radicata*	X	X			X	X	
Lagenifera gracilis	X	X			X	X	X
Lagenifera stipitata							
Olearia argophylla							X
Olearia oppositifolia						X	
Ozothamnus diosmifolius		X					
Podolepis neglecta					X	X	
Senecio amygdalifolius					X	X	X
Senecio bipinnatisectus						X	
Senecio diaschides					X		
Senecio sp. E	X	X			X	X	X
**Sigesbeckia orientalis* subsp. *orientalis*	X				X	X	

	C1	C2	C3	C4	C5	C6	C7
Asteraceae cont.							
Solenogyne bellioides						X	X
Vernonia cinerea var. *cinerea*	X				X	X	X
Vittadinia cervicularis	X						
Bignoniaceae							
Pandorea pandorana	X						X
Campanulaceae							
Wahlenbergia communis	X				X	X	
Wahlenbergia luteola	X	X			X	X	
Casuarinaceae							
Allocasuarina littoralis		X	X		X	X	
Allocasuarina torulosa	X	X			X	X	X
Celastraceae							
Celastrus australis							X
Denhamia celastroides							X
Maytenus bilocularis							X
Maytenus silvestris	X	X			X	X	X
Siphonodon australis							X
Clusiaceae							
Hypericum gramineum	X	X		X	X	X	
Convolvulaceae							
Dichondra repens	X				X	X	
Polymeria calycina	X						
Crassulaceae							
Crassula decumbens var. *decumbens*	X					X	
Cunoniaceae							
Caldcluvia paniculosa							X
Callicoma serratifolia						X	X
Ceratopetalum apetalum							X
Schizomeria ovata							X
Dilleniaceae							
Hibbertia aspera						X	
Hibbertia cistoidea		X					
Hibbertia dentata						X	X
Hibbertia obtusifolia	X	X	X		X	X	X
Hibbertia riparia						X	
Hibbertia scandens		X				X	X
Droseraceae							
Drosera auriculata		X				X	
Drosera binata				X			
Drosera spatulata				X			
Elaeocarpaceae							
Elaeocarpus reticulatus						X	X
Epacridaceae							
Acrotriche aggregata		X			X	X	X
Brachyloma daphnoides subsp. *glabrum* (Blakely) J.T. Hunter			X				
Epacris microphylla var. *microphylla*			X	X			
Epacris obtusifolia				X			

	C1	C2	C3	C4	C5	C6	C7
Epacridaceae cont.							
Leucopogon lanceolatus var. *lanceolatus*		X	X		X	X	X
Leucopogon melaleucoides		X					
Melichrus procumbens	X	X	X		X	X	
Melichrus urceolatus			X		X		
Monotoca scoparia		X	X		X	X	
Trochocarpa laurina		X			X	X	X
Escalloniaceae							
Quintinia sieberi							X
Euphorbiaceae							
Acalypha nemorum	X						
Amperea xiphoclada var. *xiphoclada*		X	X			X	
Bertya sp.		X					
Breynia cernua (Poir.) Muell.Arg.	X						X
Phyllanthus gunnii	X					X	
Phyllanthus virgatus						X	
Poranthera microphylla	X	X			X	X	X
Eupomatiaceae							
Eupomatia laurina							X
Fabaceae							
Acacia diphylla	X				X		
Acacia falciformis		X				X	
Acacia filicifolia						X	
Acacia floribunda						X	
Acacia floydii		X			X	X	X
Acacia longifolia		X					
Acacia melanoxylon							X
Acacia orites					X	X	X
Acacia ulicifolia		X	X		X	X	
Acacia venulosa		X					
Bossiaea neo-anglica				X		X	
Bossiaea scortechinii	X		X		X	X	
Daviesia villifera			X			X	
Desmodium brachpodum	X						
Desmodium rhytidophyllum	X				X	X	X
Desmodium varians	X	X			X	X	X
Dillwynia phylicoides			X				
Glycine microphylla	X	X	X		X	X	X
Glycine tabacina	X				X	X	X
Gompholobium huegelii			X				
Gompholobium uncinatum			X				
Hardenbergia violacea		X			X	X	X
Hovea linearis	X		X		X	X	
Hovea sp. A		X					
Indigofera australis					X	X	X
Jacksonia scoparia	X	X			X	X	
Mirbelia pungens	X	X					
Mirbelia speciosa subsp. *speciosa*		X					
Podolobium ilicifolium (Andrews) Crisp	X	X	X		X	X	X
Pultenaea dentata						X	
Pultenaea foliolosa			X				
Pultenaea linophylla			X				
Pultenaea retusa						X	

	C1	C2	C3	C4	C5	C6	C7
Fabaceae cont.							
Pultenaea sp. aff. *obovata*		X					
Pultenaea villosa			X	X			
Vigna vexillata var. *angustifolia*	X						
Gentianaceae							
Centaurium erythraea						X	
Geraniaceae							
Geranium retrorsum						X	
Geranium solanderi var. *solanderi*		X		X	X	X	X
Pelargonium inodorum						X	
Goodeniaceae							
Dampiera stricta			X	X		X	
Goodenia bellidifolia subsp. *argentea*			X	X	X	X	X
Goodenia hederacea subsp. *hederacea*		X				X	X
Goodenia ovata							X
Goodenia rotundifolia	X						
Haloragaceae							
Gonocarpus micranthus subsp. *micranthus*			X	X			
Gonocarpus tetragynus		X	X	X	X	X	X
Gonocarpus teucrioides		X			X	X	X
Haloragis heterophylla	X					X	
Lamiaceae							
Ajuga australis	X				X		
Mentha diemenica	X						
Plectranthus graveolens	X						
Plectranthus parviflorus	X				X	X	X
Plectranthus suaveolens		X				X	X
Prostanthera nivea	X						
Prostanthera sp. 'Boonoo Boonoo'		X					
Lauraceae							
Cassytha pubescens			X				
Lobeliaceae							
Lobelia gibbosa						X	
Pratia purpurascens	X	X			X	X	X
Loranthaceae							
Amyema congener					X	X	X
Amyema pendulum			X		X	X	
Meliaceae							
Toona australis					X		
Monimiaceae							
Palmeria scandens							X
Wilkiea huegeliana							X
Moraceae							
Ficus rubiginosa	X						
Myrsinaceae							
Rapanea howittiana							X

	C1	C2	C3	C4	C5	C6	C7
Myrtaceae							
Angophora floribunda					X		
Baeckea omissa A.R.Bean			X	X			
Backhousia myrtifolia							X
Callistemon citrinus			X	X			
Callistemon pallidus				X			
Corymbia gummifera (Sol. ex. Gaertn.) K.D.Hill & L.A.S.Johnson	X				X	X	X
Eucalyptus amplifolia						X	
Eucalyptus andrewsii			X				
Eucalyptus brunnea							X
Eucalyptus cameronii			X		X	X	X
Eucalyptus campanulata		X	X		X	X	X
Eucalyptus dorrigoensis			X				
Eucalyptus dunnii							X
Eucalyptus fusiformis	X						
Eucalyptus oreades						X	
Eucalyptus propinqua	X						
Eucalyptus saligna							X
Eucalyptus scias subsp. *apoda*		X			X	X	X
Eucalyptus williamsiana			X			X	
Leptospermum arachnoides			X	X			
Leptospermum brevipes		X					
Leptospermum gregarium				X			
Leptospermum minutifolium			X	X			
Leptospermum novae-angliae		X	X				
Leptospermum polygalifolium subsp. *montanum*							X
Leptospermum polygalifolium subsp. *transmontanum*	X	X				X	
Leptospermum trinervium		X	X				
Lophostemon confertus	X	X			X		X
Syzigium luehmannii		X					X
Nyctaginaceae							
Boerhavia dominii	X						
Oleaceae							
Notelaea longifolia forma *intermedia*	X						
Notelaea sp. A		X			X	X	X
Onagraceae							
Epilobium billardierianum subsp. *cinereum*						X	
Oxalidaceae							
Oxalis chnoodes							X
Oxalis perennans	X					X	
Piperaceae							
Peperomia tetraphylla							X
Pittosporaceae							
Billardiera scandens var. *sericata*	X	X	X		X	X	X
Bursaria spinosa var. *macrophylla*							X
Bursaria spinosa var. *obovata*		X			X		X
Citriobatus pauciflorus							X
Hymenosporum flavum							X
Rhytidosporum procumbens			X			X	

	C1	C2	C3	C4	C5	C6	C7
Plantaginaceae							
Plantago varia						X	
Polygalaceae							
Comesperma ericinum						X	
Comesperma retusum			X				
Polygala japonica	X	X				X	
Portulacaceae							
Calandrinia pickeringii	X	X					
Proteaceae							
Banksia integrifolia subsp. A					X	X	X
Banksia spinulosa var. *collina*			X				
Hakea eriantha	X	X	X		X	X	X
Hakea florulenta			X				
Lomatia silaifolia		X			X	X	
Persoonia cornifolia						X	
Persoonia lanceolata			X				
Persoonia oleoides		X	X		X	X	X
Persoonia sericea	X	X	X		X	X	
Persoonia tenuifolia			X				
Petrophile canescens			X		X		
Ranunculaceae							
Clematis aristata						X	X
Ranunculus inundatus						X	
Ranunculus lappaceus		X				X	
Rhamnaceae							
Pomaderris elliptica	X						
Pomaderris lanigera			X				
Pomaderris notata		X					
Rosaceae							
Rubus moluccanus L. subsp. *moluccanus*							X
Rubus parvifolius						X	
Rubiaceae							
Canthium coprosmoides						X	X
Galium migrans					X	X	X
Galium propinquum							X
Opercularia hispida	X				X	X	
Pomax umbellata	X	X	X		X	X	X
Randia chartacea							X
Rutaceae							
Boronia algida			X				
Boronia parviflora				X			
Correa reflexa	X	X					
Phebalium squamulosum		X					
Philotheca myoporoides subsp. *epilosus* (Paul G.Wilson) M.J.Bayly		X					
Melicope hayesii						X	X
Santalaceae							
Choretrum candollei		X	X		X	X	
Exocarpus cupressiformis						X	
Scrophulariaceae							
Veronica calycina							X

	C1	C2	C3	C4	C5	C6	C7
Solanaceae							
Solanum campanulatum	X	X			X	X	X
Stackhousiaceae							
Stackhousia muricata		X		X			
Sterculiaceae							
Brachychiton populneus subsp. *populneus*	X						
Lasiopetalum ferrugineum var. *cordatum*	X						
Lasiopetalum ferrugineum var. *ferrugineum*			X				
Stylidiaceae							
Stylidium graminifolium			X		X	X	
Stylidium laricifolium		X					
Symplocaceae							
Symplocos thwaitesii							X
Thymelaeaceae							
Pimelea linifolia		X	X			X	
Tremandraceae							
Tetratheca thymifolia						X	
Ulmaceae							
Trema tomentosa var. *viridis*	X				X		
Urticaceae							
Elatostema reticulatum var. *reticulatum*	X						X
Verbenaceae							
Clerodendrum floribundum							X
Gmelina leichhardtii							X
Violaceae							
Hybanthus monopetalus	X		X		X		
Hybanthus stellarioides (Domin) P.I.Forst.	X				X		
Viola betonicifolia	X	X			X	X	X
Viola hederacea	X	X			X	X	X
Vitaceae							
Cayratia clematidea						X	
Cissus hypoglauca							X
Winteraceae							
Tasmannia insipida							X

Vegetation and floristics of Kwiambal National Park and surrounds, Ashford, New South Wales

John T. Hunter, Jennifer Kingston and Peter Croft

John T. Hunter[1], Jennifer Kingston[2] and Peter Croft[2] ([1]75 Kendall Rd, Invergowrie, NSW 2350, [2]Glen Innes District National Parks and Wildlife Service, Glen Innes, NSW 2370) 1999. Vegetation and floristics of Kwiambal National Park and surrounds, Ashford, New South Wales. Cunninghamia *6(2): 351–378*

The vegetation of Kwiambal National Park and surrounds, 30 km north-west of Ashford (29°07'S, 150°58'E) in the Inverell Shire on the North Western Slopes, is described. Eight plant communities are defined based on flexible UPGMA analysis of relative abundance scores of vascular plant taxa. These communities are mapped based on ground truthing, air photo interpretation and geological substrate. All communities are of woodland structure and most are dominated by *Callitris glaucophylla, Eucalyptus melanophloia* and *Eucalyptus dealbata*. Communities are: 1) Mixed Stand Woodland (Dry Rainforest), 2) Granite Woodland, 3) Metasediment Woodland, 4) Riverine, 5) Metabasalt Woodland, 6) Granite Open Woodland, 7) Limestone Woodland, and 8) Alluvial Woodland.

Many of the taxa (407 species were recorded) show phytogeographic affinities with western south-east Queensland flora. This is also true of the communities defined. Five ROTAP listed species have been found in the Park: *Acacia williamsiana, Astrotricha roddii, Euphorbia sarcostemmoides, Olearia gravis* and *Thesium australe*, three of these are listed on the NSW Threatened Species Conservation Act (1995). Another ten taxa are considered to be at their geographic limit or disjunct in their distribution. 17% are exotic in origin.

Introduction

Kwiambal National Park is approximately 130 km north-west of Glen Innes and 30 km north-west of Ashford (29°07'S, 150°58'E) in the Shire of Inverell on the North Western Slopes of NSW (Fig. 1). The most recent proposal for Kwiambal National Park included 3487 ha and included the crown reserves of Macintyre Falls and the Limestone Caves and surrounding land purchases made by the NSW National Parks and Wildlife Service in 1994 (Inverell Shire, County of Arrawatta, Parish of Limestone, Portions 9, 10, 11, 12, 13, 15 and 23). The Park was announced on 17 July 1998 and included the crown reserves and portions 11 and 15 (c. 1200 ha). The National Parks and Wildlife Service owns approximately 2300 ha adjoining the park, which is not yet declared but is expected to be so. The original proposal for a 'Macintyre Falls National Park' included a much larger area of 13 540 ha (Roberts 1982).

Kwiambal National Park is within one of the largest areas of remnant woodlands in the North Western Slopes Botanical District and is in the Northern Complex Province of the Nandewar Biogeographic Region (NAN). These areas are poorly represented in the current reserve network. The junction of the Severn and Macintyre rivers forms the

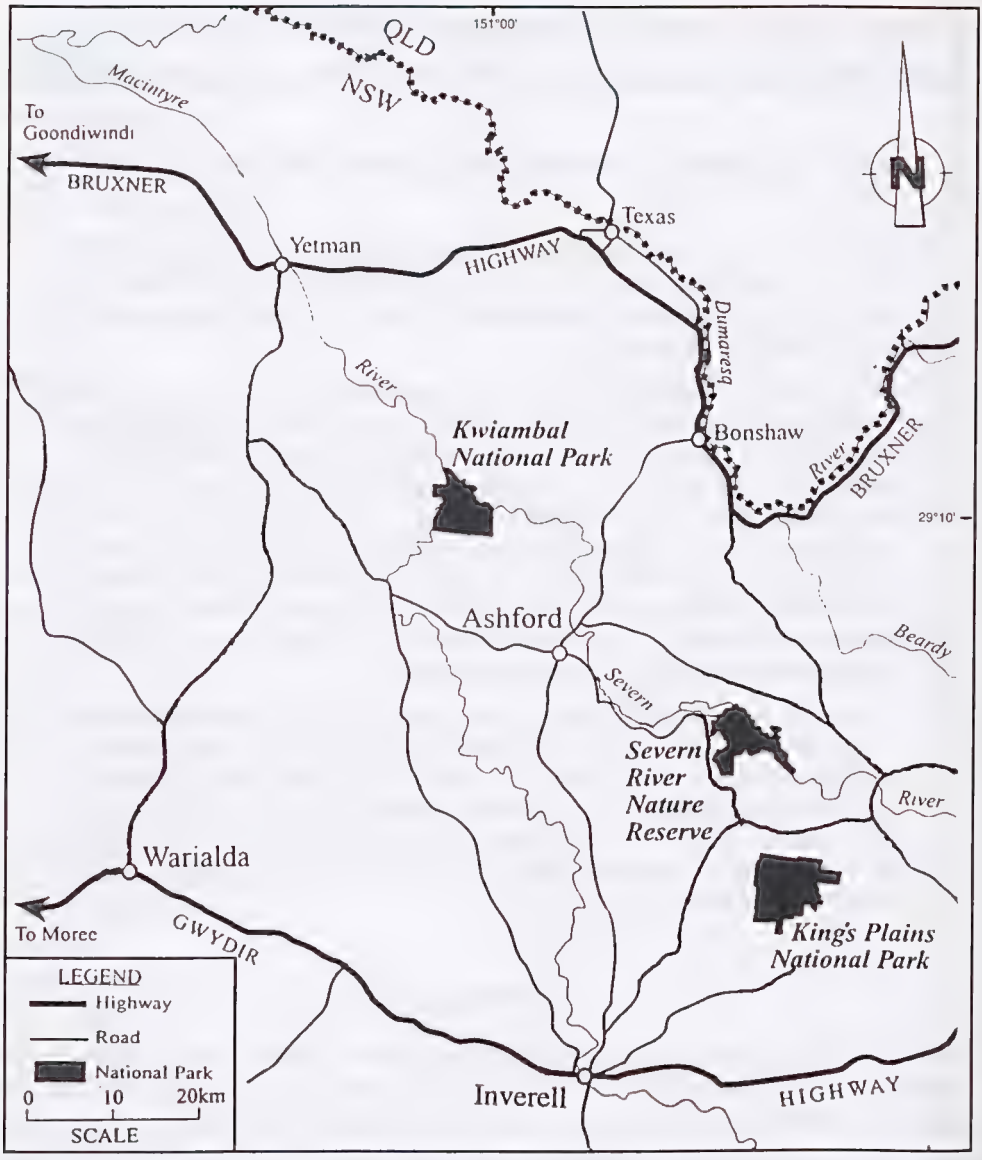

Fig. 1. Map of locality of the Kwiambal National Park.

north-western corner of the Park and both rivers demarcate most of the north and western boundaries. Severn State Forest lies on the northern boundary of the Park. The name Kwiambal is derived from the aboriginal group that originally inhabited the region (Howell 1982).

This paper gives part of the results of a flora survey conducted on behalf of the Glen Innes District of the NSW National Parks and Wildlife Service. The aims of this study were to provide a vegetation map of communities to assist in fire management of the Park and to provide information on the distribution of rare, geographically restricted

or disjunct taxa within the Park. This information will be used to develop appropriate management strategies for the Park (Hunter 1998).

Climate

The climate of Kwiambal is typical of the northern part of the North Western Slopes. Winds are mainly from the south-west in summer. Dry thunderstorms are common throughout spring. On average one in every five years are drought years (Division of National Mapping 1986), however the five years between 1992 and 1996 were drought declared years. Summers are hot with the average maximum temperature for the warmest period being around 31–32°C and winters are cold with the average minimum temperature of the coldest period being between 1–3°C (McMahon 1995). Annual precipitation is around 640 to 670 mm (McMahon 1995). Humidity is low in summer — around 55% — and up to 76% in winter.

Geology and geomorphology

Kwiambal National Park is located in the Kwiambal Terrane (Flood et al. 1994) which is thought to be an accreted seamount. This terrane is situated within the Anaiwan Terrane of the southern New England Orogen of eastern Australia. The New England Orogen is a collage of a number of terranes that amalgamated and accreted to the eastern margin of Gondwana during the late Paleozoic-early Mesozoic (Flood & Aitchison 1993). The seamont formed at a hotspot at the mid-ocean ridge during the Early Carboniferous (Flood & Aitchison 1993).

There are four major rock types within the Park: metabasalts (5%), limestones (3%), greywackes (Texas Bed sediments: 16%) and granites (76%). These rocks have been variously metamorphosed, deformed, mineralised and altered.

The Park landscape is rugged, with low rocky ridges interspersed with small undulating areas of deeper soils in gullies or on plateaus (Roberts 1982). Altitudes are predominantly between 300 and 500 m above sea level. Two large rivers, the Macintyre and Severn, both become entrenched in their lower sections with steep sided valleys. Both river valleys begin with waterfalls 2–3 km upstream from their confluence. The caves area to the south is disjunct from the main section of the Park and has limestone outcrops and a major cave 548.6 m long.

History and Landuse

Settlers arrived in the area prior to 1830. Allan Cunningham is his exploration of the area north of Inverell in 1827 found a squatter's shack and cattle in this supposedly unexplored region (McMinn 1970). Ashford was dedicated as a village in 1860.

The main land uses in Ashford today involve the wool and cattle industries. Tobacco growing was once the largest industry within the area but is no longer carried out. Logging and sawmilling began around 1900.

Selective logging has taken place throughout most areas that are now within Kwiambal National Park, apart from the original crown reserves. Logging began around 1900 and re-logging occurred in the 1940s, 1950s and was being carried out in

portion 13 in the 1980s (Roberts 1982). Clearing for grazing and tobacco has been the other main disturbance. Tobacco growing occurred between 1969 and 1994 within the boundaries of the present Park. There has been guano mining at the caves and mining for marble has been suggested, but has never occurred. Tourism within the Park is concentrated on Macintyre Falls and the limestone caves to the south.

Previous investigations

In 1827 the botanist Allan Cunningham collected in the general vicinity of Kwiambal crossing ridges covered with stunted ironbark and *Callitris* (McMinn 1970). Turner (1905) traversed much of the North Western Slopes describing the vegetation of the region. Even as early as this, many weeds were found amongst natural vegetation and Prickly Pear (*Opuntia* sp.) at Apple Tree Flat within Kwiambal was described as being so thick that it could not be walked through.

Roberts (1982) produced a proposal for the Macintyre Falls National Park and in his thesis on the vegetation of granite areas of northern New South Wales (Roberts 1983) broadly described the major vegetation types and dominant species. Le Brocque & Benson (1995) surveyed 105 vegetation sites across the Ashford 1:100 000 map sheet and reported on the major vegetation communities. A few of these sites were within the boundaries of the proposed park. The NSW National Parks and Wildlife Service commissioned a survey of 30 sites within land purchased by the Service in what was to become the basis of Kwiambal, though no analyses or vegetation maps were produced. Hunter (Hunter & Clarke 1998) also visited the Kwiambal and Severn State Forest areas in 1995, and 19 floristic sites for a broader survey of the granitic outcrop vegetation of the New England Batholith. Nadolny et al. (1997) surveyed populations of the rare *Astrotricha roddii* and assessed the associated vegetation.

Methods

The initial procedure for stratifying sites involved the use of previously collected survey data, in particular that of the National Parks and Wildlife Service, Le Brocque & Benson (1995) and Hunter & Clarke (1998). It was envisaged that these sites would provide a basis for development of a vegetation map and that only minimal number of additional sites would be needed. This however, was found inappropriate in the light of the type of information gathered previously and the various methods used, and a new survey was necessary. The new survey involved recording of 42, 20 × 20 m quadrats within which the cover-abundance of all vascular plant species was determined using the Braun-Blanquet (1982) cover abundance scale. Quadrats were placed using a stratified random method. As only a relatively low number of sites was used, only a minimal combination of environmental attributes could be chosen in order to allow for replication. Physiography, geology and altitude were used to stratify sites as these were important in the delineation of communities in trial analyses, and were shown to be important in the study of Le Brocque & Benson (1995). The current survey was conducted over three weeks in late October and early November in 1997.

Good quality material of many taxa was retained as vouchers and sent to the N.C.W. Beadle Herbarium of the University of New England (NE) in the first instance and then to the National Herbarium of New South Wales (NSW) or the Coffs Harbour Herbarium (CFSHB). Taxon nomenclature follows that of Harden (1990–1993) except where recent changes have been made.

Analyses and data exploration were performed using options available in the PATN Analysis Package (Belbin 1995a, b). For final presentation of results all species and their relative abundance scores were used and the analysis performed using Kulczynski association measure which is recommended for ecological applications (Belbin 1995a, b) along with flexible UPGMA and the default PATN settings.

Delineation of community boundaries in Fig. 3 was based on the location of sites and their position within the multivariate analysis and on previous survey plots and their floristic composition, air photograph interpretation and ground truthing. The vegetation map is based on 1:50 000 topographic maps. Structural names follow Specht et al. (1995) and are based on the most consistent uppermost stratum.

Results

Eight communities where recognised at the dissimilarity measure of 0.72 (Figs 2 and 3). A dissimilarity of 0.72 is similar to the 0.75 used for community definition on the Ashford sheet by Le Brocque & Benson (1995). Community relationships are given by the dendrogram (Fig. 2). This is slightly divergent from the original dendrogram produced by the Kulczynski analysis which recognised an additional community at 0.72 dissimilarity. On inspection of subsequent analyses and the two-way table of species against sites, it was decided that this site was an outlier, divergent from other sites due to the large number of exotic taxa and excessive disturbance. It was removed from the dataset, which was re-analysed.

Vegetation communities

All plant communities in Kwiambal National Park, except for some riverine areas, are dominated by *Callitris glaucophylla* (White Cypress Pine), *Eucalyptus melanophloia* (Silver-leaved Ironbark) and *Eucalyptus dealbata* (Tumbledown Gum). The relative importance of these three tree species changes within different communities. More important in defining the communities are the additional co-dominants and the understorey taxa. Some communities have very few species with high fidelity. For example Community 2 is defined primarily by widespread taxa and those that are lacking. In contrast, other communities such as 1 and 3 contain distinct assemblages and have a number of indicator species. The eight communities are mapped (Fig. 3). Selected attributes of each of the defined communities are given in Table 1.

Community 1: Mixed Stands Woodland (Dry Rainforest)

Alphitonia excelsa (Red Ash)–*Corymbia dolichocarpa* (Large-fruited Bloodwood)–*Eucalyptus caleyi* (Caley's Ironbark)–*Angophora leiocalyx* (Smooth-barked Apple) Woodland.

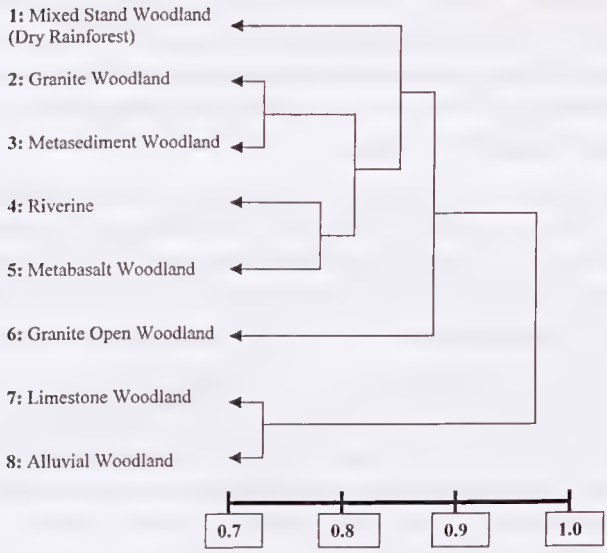

Fig. 2. Summary dendogram of the full florisitic dataset of site using Kulczynski association and flexible UPGMA fusion strategy and a β value of -0.1. Communities have been defined at a dissimiliarity level of 0.72.

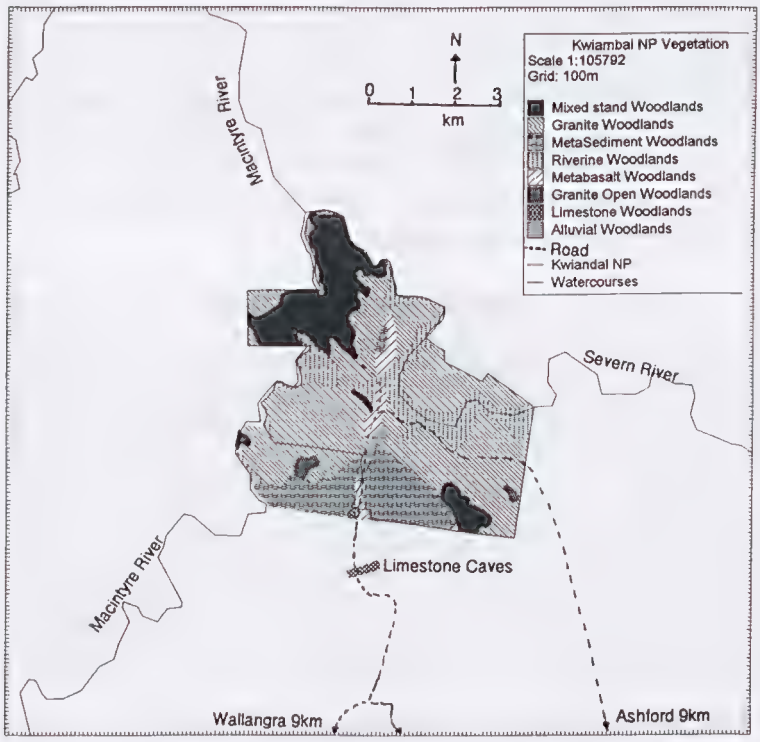

Fig. 3. Map of vegetation communities for Kwiambal National Park and adjoining lands purchased by the NSW National Parks and Wildlife Service. The disjunct limestone caves area is not yet joined to the main Park. Scale = 1:50 000.

Structure: Woodland: Tree layer usually 15–20 m or to 30 m tall, 15–40% cover. Shrubs or small trees often in two layers 10–15 m and 3–10 m tall, 30–50% cover. Ground cover variable, 40–90%.

Trees: *Alphitonia excelsa, Eucalyptus dealbata, Callitris glaucophylla, Brachychiton populneus, Eucalyptus melanophloia, Acacia williamsiana, Corymbia dolichocarpa, Eucalyptus caleyi, Angophora leiocarpa, Eucalyptus populnea, Eucalyptus crebra.*

Shrubs: *Acacia leiocalyx, Leptospermum brevipes, Notelaea microcarpa, Melichrus urceolatus, Breynia cernua, Alstonia constricta, Bertya oleifolia, Olearia gravis, Acacia pruinosa, Santalum lanceolatum, Santalum acuminatum, Ficus rubiginosa, Astrotricha roddii, Hovea lanceolata, Phyllanthus carpentariae, Abutilon oxycarpum, Canthium odoratum, Petalostigma pubescens, Beyeria viscosa, Alectryon subdentatus.*

Climbers: *Jasminum lineare, Pandorea pandorana, Euphorbia sarcostemmoides, Parsonsia eucalyptophylla.*

Ground cover: *Aristida vagans, Cymbopogon refractus, Wahlenbergia communis, Cheilanthes distans, Commelina cyanea, Lomandra longifolia, Sigesbeckia australis, Microlaena stipoides, Scleria mackaviensis, Austrostipa drummondii, Calotis dentex, Lepidosperma laterale, Daucus glochidiatus, Dichondra* sp. A, *Cheilanthes sieberi* subsp. *sieberi, Einadia hastata.*

Variability: This group contains a variable assemblage of dominants or co-dominants. Woodlands of *Alphitonia excelsa, Eucalyptus dealbata, Callitris glaucophylla, Brachychiton populneus* and *Corymbia dolichocarpa* on the sides of rocky hills are the most common. However, on higher ridge tops particularly on the western side of the Macintyre River, *Alphitonia excelsa, Acacia williamsiana* and *Brachychiton populneus* may dominate. Often a dense layer of *Plectranthus parviflorus* is present. On valley floors with deeper alluvium or more gently sloping hillsides a mixture of *Angophora leiocarpa, Eucalyptus dealbata, Callitris glaucophylla, Eucalyptus crebra* and *Eucalyptus populnea* may become common with a dense understorey of *Acacia leiocalyx* and or *Leptospermum brevipes.*

Community 2: Granite Woodlands

Callitris glaucophylla (White Cypress Pine)–*Eucalyptus dealbata* (Tumbledown Gum)–*Angophora floribunda* (Rough-barked Apple)–*Eucalyptus melanophloia* (Silver-leaved Ironbark) Woodland.

Structure: Woodland: Tree layer usually 15–20 m or to 30 m, 30–50% cover. Shrubs 3–10 m tall, 15–20% or sometimes to 40% cover. Ground cover 70–90%.

Trees: *Callitris glaucophylla, Eucalyptus dealbata, Angophora floribunda, Eucalyptus melanophloia, Brachychiton populneus, Eucalyptus caleyi.*

Shrubs: *Leptospermum brevipes, Melichrus urceolatus, Desmodium brachypodum, Acacia leiocalyx, Acacia pruinosa, Hibbertia obtusifolia, Notelaea microcarpa, Canthium odoratum, Correa reflexa, Hovea lanceolata, Acacia neriifolia, Alphitonia excelsa, Breynia cernua, Calytrix tetragona, Olearia elliptica, Brachyloma daphnoides.*

Climbers: *Pandorea pandorana.*

Ground cover: *Aristida vagans, Cymbopogon refractus, Dichondra* sp. A, *Aristida ramosa, Cheilanthes sieberi* subsp. *sieberi, Vittadinia sulcata, Cheilanthes distans, Austrostipa drummondii, Cyperus gracilis, Echinopogon ovatus, Senecio diaschides, Wahlenbergia communis, Arthropodium milleflorum, Calotis lappulaceae, Commelina cyanea, Daucus glochidiatus, Lomandra multiflora, Dianella caerulea, Entolasia stricta.*

Variability: This assemblage is usually dominated by *Callitris glaucophylla, Eucalyptus dealbata* and *Eucalyptus melanophloia*. In rockier situations, *Brachychiton populneus* and *Eucalyptus caleyi* may become more common. In places with a deeper soil profile near creek lines, *Angophora floribunda* becomes prominent.

Community 3: Metasediment Woodlands

Callitris glaucophylla (White Cypress Pine)–*Eucalyptus melanophloia* (Silver-leaved Ironbark)–*Eucalyptus albens* (White Box)–*Eucalyptus dealbata* (Tumbledown Gum).

Structure: Woodland: Tree layer usually 15–20 m tall but to 30 m, cover 20–40%. Shrubs 1–5 m tall, 15–30% or sometimes to 40% cover. Ground cover 40–90%.

Trees: *Callitris glaucophylla, Eucalyptus melanophloia, Eucalyptus albens, Eucalyptus dealbata, Brachychiton populneus.*

Shrubs: *Olearia elliptica, Acacia leiocalyx, Notelaea microcarpa, Desmodium brachypodum, Canthium odoratum, Cassinia uncata, Hibbertia obtusifolia, Eremophila debilis, Styphelia triflora, Dodonaea viscosa, Swainsona queenslandica, Leucopogon muticus.*

Climbers: *Pandorea pandorana, Jasminum lineare, Parsonsia eucalyptophylla, Jasminum sauvissimum.*

Ground Cover: *Aristida ramosa, Cheilanthes distans, Dichondra* sp. A, *Desmodium varians, Cheilanthes sieberi* subsp. *sieberi, Panicum simile, Glossogyne tannensis, Thonandia longifolia, Aristida vagans, Calotis lappulaceae, Wahlenbergia communis, Scleria mackaviensis, Stemodia glabella, Austrostipa drummondii, Vittadinia sulcata, Chamaesyce drummondii, Cyperus gracilis, Goodenia hederacea, Brachyscome microcarpa, Commelina cyanea.*

Variability: Community 3 is restricted to the metasediments that form a large portion south of the current reserve. *Eucalyptus albens* forms a conspicuous part of this association on deeper soils on portion 13. *Eucalyptus albens* is sometimes interspersed within Community 8 where the two communities abut. This type of mosaic was recognised by Beadle (1981) who describes *E. albens* as usually occurring on elevated sites but intergrading with *E. blakelyi* and *E. melliodora* which occur along watercourses. This kind of interchange is common throughout the range of these species (Prober 1996, Fisher & Goldney 1997). *Eucalyptus melanophloia* is known to replace *E. albens* on poorer soils (Prober & Theile 1993) and this occurs away from the road to the south of the current reserve.

Community 4: Riverine Woodlands

Eucalyptus blakelyi (Blakely's Red Gum)–*Angophora floribunda* (Rough-barked Apple)–*Eucalyptus camaldulensis* (River Red Gum).

Structure: Woodland: Tree layer 20–30 m tall, 20-30% cover. Shrubs 3–10 m tall, 5–20% cover. Ground cover 90–100%.

Trees: *Eucalyptus blakelyi, Callitris glaucophylla, Angophora floribunda, Eucalyptus camaldulensis, Brachychiton populneus, Eucalyptus melanophloia, Casuarina cunninghamiana.*

Shrubs: *Leptospermum brevipes, Swainsona galegifolia, Acacia leiocalyx, Notelaea microcarpa, Callistemon viminalis, Hibbertia obtusifolia, Hovea lanceolata, Solanum americanum.*

Climbers: *Parsonsia eucalyptophylla, Jasminum lineare, Clematis glycinoides, Eustrephus latifolius.*

Ground cover: *Arundinella nepalensis, Vittadinia sulcata, Cyperus gracilis, Juncus ochrocoleus, Lomandra longifolia, Oxalis perennans, Aristida ramosa, Aristida vagans, Commelina cyanea, Dichondra* sp. A, *Ranunculus sessiliflorus, Daucus glochidiatus, Panicum simile, Rumex brownii, Austrostipa drummondii, Carex incomitata, Cheilanthes sieberi* subsp. *sieberi, Poa sieberiana, Pratia purpurascens, Ajuga australis, Cymbopogon refractus, Dichondra repens, Dichonopogon fimbriatus, Echinopogon ovatus, Einadia hastata, Haloragis heterophylla, Lomandra multiflora.*

Variability: Non-rocky areas on the river banks with deeper alluvium have *Eucalyptus camaldulensis* as a dominant, areas further from the river banks on alluvium and even along minor creeks *Eucalyptus blakelyi* becomes prominent. Where the riverbanks become rockier *Casuarina cunninghamiana* becomes more prominent.

Community 5: Metasediment Woodlands

Eucalyptus melanophloia (Grey Ironbark)–*Callitris glaucophylla* (White Cypress Pine).

Structure: Woodland: Trees usually only 15 m tall but to 20 m, cover 20–40%. Shrubs 2–4 m tall, with 10–40% cover. Ground cover 90–100%.

Trees: *Eucalyptus melanophloia, Callitris glaucophylla.*

Shrubs: *Swainsona galegifolia, Desmodium brachypodum, Olearia elliptica, Hibbertia obtusifolia, Notelaea microcarpa, Pimelea neo-anglica, Bertya oleifolia, Melichrus urceolatus, Cassinia uncata.*

Climbers: *Parsonsia eucalyptophylla, Jasminum lineare.*

Ground cover: *Dichondra* sp. A, *Daucus glochidiatus, Ajuga australis, Cymbopogon refractus, Austrostipa drummondii, Vittadinia sulcata, Cyperus gracilis, Ranunculus sessiliflorus, Calotis lappulaceae, Brunoniella australis, Lomandra longifolia, Thesium australe, Aristida ramosa, Arthropodium milleflorum, Cheilanthes distans, Cheilanthes sieberi* subp. *sieberi, Desmodium varians, Einadia hastata, Galium gaudichaudii, Mentha diemenica, Plantago varia, Vernonia cinerea, Wahlenbergia communis.*

Variability: The presence or absence of *Olearia elliptica* is the main visual difference within this community.

Community 6: Granite Open Woodlands

Callitris endlicheri (Black Cypress Pine)–*Callitris glaucophylla* (White Cypress Pine)–*Eucalyptus dealbata* (Tumbledown Gum).

Structure: Open Woodland: Trees when dominant to 15 m tall, 10–20% cover. Shrubs 1.5–5 m tall, 10–30% cover. Ground cover variable 20–80% depending on the amount of exposed rock.

Trees: *Callitris endlicheri, Callitris glaucophylla, Eucalyptus dealbata, Eucalyptus melanophloia, Brachychiton populneus.*

Shrubs: *Leptospermum brevipes, Melichrus urceolatus, Acacia leiocalyx, Canthium odoratum, Calytrix tetragona, Cryptandra amara, Hovea lanceolata, Acacia williamsiana, Alphitonia excelsa, Leucopogon muticus, Phyllanthus carpentariae.*

Climbers: None apparent.

Ground cover: *Aristida ramosa, Tripogon loliiformis, Aristida vagans, Eragrostis elongata, Cheilanthes sieberi* subp. *sieberi, Digitaria breviglumis, Cheilanthes distans, Commelina cyanea, Goodenia hederacea, Laxmannia compacta, Lepidosperma laterale, Phyllanthus virgatus, Actinotus helianthi, Brachycome microcarpa, Evolvulus alsinoides, Fimbristylis dichotoma, Glossogyne tannensis, Goodenia bellidifolia, Murdannia graminea, Stypandra glauca, Wahlenbergia communis.*

Variability: This community type is highly variable. Due to its disjunct nature, opportunistic occurrences of taxa may often give a different appearance. For example, the presence or absence of *Callitris endlicheri* or some other major component will visually change the community; however, the overall floristics are relatively similar. The major differences are between rock outcrops and dry hillsides, again mainly in visual appearance.

Community 7: Limestone Woodlands

Callitris glaucophylla (White Cypress Pine)–*Angophora floribunda* (Rough-barked Apple)–*Brachychiton populneus* (Kurrajong)–*Eucalyptus albens* (White Box).

Structure: Woodland: Tree layer 20–25 m tall, 20–30% cover. Shrubs 1–3 m tall. 5–10% cover. Ground cover 90–100%.

Trees: *Callitris glaucophylla, Angophora floribunda, Brachychiton populneus, Eucalyptus albens, Eucalyptus melanophloia.*

Shrubs: *Notelaea microcarpa, Desmodium brachypodum, Pimelea neo-anglica, Solanum cinereum, Canthium odoratum.*

Climbers: *Glycine latifolia, Eustrephus latifolius, Clematis glycinoides, Rubus parvifolius, Parsonsia straminea.*

Ground cover: *Dichondra* sp. A., *Microlaena stipoides, Adiantum aethiopicum, Plantago debilis, Geranium solanderi, Lomandra longifolia, Aristida ramosa, Cheilanthes sieberi, Wahlenbergia communis, Lomandra confertifolia, Glycine tabacina, Glycine clandestina, Cymbopogon refractus, Stemodia glabella, Desmodium varians, Daucus glochidiatus, Calotis lappulaceae, Veronica calycina, Oxalis perennans, Eremophila deserti, Dianella caerulea.*

Variability: Only a small amount of this community exists within the park and therefore the variability is minimal. The amount of limestone outcrop affects the density of the tree layer.

Community 8: Alluvial Woodlands

Eucalyptus melliodora (Yellow Box)–*Eucalyptus blakelyi* (Blakely's Red Gum)–*Callitris glaucophylla* (White Cypress Pine).

Structure: Woodland: Trees 20–25 m tall, c. 30% cover. Shrubs to 5 m tall, 5% cover. Ground cover 100%.

Trees: *Eucalyptus melliodora, Callitris glaucophylla, Brachychiton populneus, Eucalyptus blakelyi.*

Shrubs: *Notelaea microcarpa, Swainsona queenslandica, Acacia leiocalyx.*

Climbers: None apparent.

Ground cover: *Dichondra* sp. A, *Aristida ramosa, Cheilanthes sieberi* subsp. *sieberi, Stemodia glabella, Desmodium varians, Daucus glochidiatus, Calotis lappulaceae, Mentha satureioides, Mentha diemenica, Lomandra multiflora, Euchiton sphaericus, Cyperus squarrosus, Brunoniella australis, Microlaena stipoides, Plantago debilis, Geranium solanderi, Veronica calycina, Oxalis perennans, Vittadinia dissecta, Ranunculus lappaceus, Einadia hastata, Cynoglossum australe, Chamaesyce drummondii, Arthropodium milleflorum.*

Variability: Very little of this community exists to the south of the current reserve and so little variation is noticeable, most of which is probably due to intergradation with other defined communities. *Callistemon viminalis* becomes dominant in the understorey closer to the creek line. *Eucalyptus albens* grades into this community further away from the creek.

Discussion

Vegetation communities

The presence of dry rainforest taxa is a feature of the Mixed Stands and distinguishes it from all other communities recognised within the Park. Beadle (1981) named associations such as these 'mixed stands' and described them as occurring on rocky outcrops as far south as Gunnedah. Such communities fit into the Webb (1978) structural category of semi-evergreen vine thicket. Floyd (1990) placed such assemblages within his Suballiance No. 32 *Notelaea microcarpa–Ehretia membranifolia–Geijera parviflora* for his rainforest classification of New South Wales and includes vegetation as far south as the Hunter Valley and north to Toowoomba. The annual rainfall of around 660 mm for Kwiambal is close to the range specified by Floyd (1990) for optimal development of this community type (i.e. 575–650 mm).

Benson et al. (1996) present a review of current knowledge of dry rainforest communities of north-eastern New South Wales in their discussion of Derra Derra Ridge. Although they have mapped major and minor occurrences of this assemblage, those at Kwiambal are not included. Almost all previous occurrences of this association are on deep, loamy and high nutrient soils derived from basalt (Benson et al. 1996). At Kwiambal, this community type is restricted to granite and this may explain why it is depauperate in comparison to those described at Derra Derra Ridge.

Community 1 is unlike the dry rainforest described for the Hunter region (Floyd 1990; Turner & Vernon 1994) or Mt Kaputar (Fox 1994). However, there is a remarkable overall resemblance to communities and taxa described and listed for Derra Derra Ridge (Benson et al. 1996) and Planchonella Hill (Henderson 1997, Williams 1998). A similar community is defined by Le Brocque & Benson (1995) as Community 9 *Eucalyptus melanophloia/Callitris glaucophylla* association with a dry rainforest sub-component. Le Brocque and Benson (1995) describe their community as being confined to the north of the Ashford map sheet, particularly in Queensland where it is found on granite and sedimentary soils. Further extensions of this community are known within the Severn State Forest and on private property to the north and west of the national park. It is apparent the mixed stands at Kwiambal are directly synonymous with those stands found on granite on the Ashford sheet by Le Brocque & Benson (1995). Further research into the variability of these communities and their relationships is warranted for a greater understanding of their threats, processes and floristic resemblances to other semi-evergreen vine thickets.

Angophora leiocarpa is usually only known from wide sandy valleys derived from sandstone primarily on the North Western Slopes and Plains of New South Wales and also central Queensland (Neldner 1984, Leach 1986, Young & McDonald 1989, Hill 1991, Carr 1996). Beadle (1981) placed *Angophora leiocarpa* in a Suballiance of *Eucalyptus crebra* and refers to it being common in sandstone areas and notes that they have been termed 'sandstone woodlands' by other authors. This assemblage occurring on granite was recognised by Le Brocque & Benson (1995) and termed Community 2 *Eucalyptus crebra/Angophora leiocarpa* association in their report on the vegetation of the Ashford sheet.

Community 2 can be recognised by the lack of species that are used to distinguish other communities. Most of the species within Granite Woodland are ubiquitous, in particular the overstorey components. This association of dominants is widespread in central Queensland (Neldner 1984) but appears to be of limited extent within New South Wales. Granite Woodland is probably synonymous with Community 11 *Eucalyptus dealbata/E. caleyi/E. melanophloia/Callitris* spp. association of Le Brocque & Benson (1995). Their community was located near Kwiambal on the Ashford map sheet, apart from a single occurrence near the Beardy River.

Metasediment Woodlands often contained *Eucalyptus albens*, which was not noted on granite within the Park. *Brunoniella australis* is a good indicator species for metasediments. Often where granite and metasediments abut, the two communities (2 and 3) can be separated visually by the presence of either *Olearia elliptica* on metasediments or *Leptospermum brevipes* on granite. It is interesting to note that both *Olearia elliptica* and *Leptospermum brevipes* will grow well on either rock type, however they grow in different topological positions. These preferences mean that where the two geological strata are together, *Olearia elliptica* is usually present on the metasediments and *Leptospermum brevipes* is present on the granite. Another noticeable difference with Metasediment Woodlands is the rarity of *Alphitonia excelsa* and lack of the dry rainforest species found in Mixed Stands. Young and McDonald (1989) describe *Eucalyptus melanophloia, E. dealbata, E. albens* communities with a similar

understorey as occurring along the Severn River west of Ballandean on traprock on their map of the vegetation of Warwick. Benson et al. (1996) describe a *Eucalyptus melanophloia, Eucalyptus albens* and *Callitris glaucophylla* association with similar understorey on basalt for Derra Derra Ridge. The only other occurrences of this type of association appears to be restricted to the Peel and Gwydir Valleys (Prober 1996). Le Brocque & Benson (1995) did not record *Eucalyptus albens* in their survey of the Ashford sheet but did record the often associated *Eucalyptus moluccana*. Beadle (1981) describes *Eucalyptus albens* as being particularly common on soils with a high base status particularly in calcium and generally of high fertility.

Shrubs are rare in the Riverine community, however introduced species are widespread. *Eucalyptus blakelyi* associations usually contain *Eucalyptus melliodora* and the reason why this species is absent from this community is unknown. This community has a very sparse or sometimes non-existent shrub layer but has a very diverse exotic forb component that appears to be common wherever it occurs (Beadle 1981, Sivertsen & Metcalf 1995). Communities similar to these probably occur from Victoria through the western slopes of New South Wales and into Queensland (Specht et al. 1995).

With the exception of *Olearia elliptica*, which forms a dense stand across the top of the Metabasalt lenses, shrubs are also rare in Metabasalt Woodland. Forbs form a major component of this community. Stunted, almost mono-specific stands of *Eucalyptus melanophloia* dominate. Neldner (1984) notes that it is common for *Eucalyptus melanophloia* to form mono-dominant stands on clay soils derived from basalt colluvium.

Most rock outcrop areas within Kwiambal have Mixed Stands however, this community also occurs below outcrops and along the riverbanks. Granite Open Woodland is entirely restricted to rock outcrops. Hunter and Clarke (1998) in their survey of granite outcrop communities term Community 6 *Aristida vagans–Tripogon loliiformis* grassland.

Limestone Woodland is restricted in its distribution and is found only on limestone areas particularly where this outcrops. There is a high incidence of introduced taxa on limestone outcrops within Limestone Woodland, and in particular *Hyparrhenia hirta* is prevalent. A unique assemblage of herbs is found in areas with this community.

Phytogeography

Kwiambal National Park lies within the Northern Complex Province of the Nandewar Biogeographic Region (NAN). However, there is a high affinity of taxa found within Kwiambal for south central Queensland (Hunter 1998). Kwiambal has many species that are at or somewhat near their southern limit of distribution. For instance, the trees *Corymbia dolichocarpa* and *Angophora leiocarpa* have their main occurrence within central Queensland. Shrub species such as *Phyllanthus carpentariae* or *Euphorbia sarcostemmoides* are more common in the Northern Territory. Mixed Stand has its greatest affinities with other communities found in Queensland and its southern affinities probably lie only as far south as Derra Derra Ridge. Kwiambal does fit within interzone 3 of Burbidge (1960), a much older representation of biogeographical

regions. Certainly, the communities and many of the species show little resemblance to other areas within the Nandewar Biogeographic Region.

Species richness

The total number of taxa is of note as Le Brocque & Benson (1995) in their survey of 105 sites across the Ashford map sheet found 290 taxa. They also noted that only a further 213 species had been previously recorded for the map sheet (503 taxa in total).

The current survey of the Park and nearby areas followed a period of good rainfall; many taxa found were ephemeral in nature. The low numbers of taxa found by Le Brocque & Benson (1995) were attributed to drought conditions within the area. This difference in floristic richness highlights the importance of timing in floristic surveys in semi-arid regions of Australia. A total of 407 vascular plant taxa was recorded from the collation of existing site data and this present survey. Approximately 17% (69) of all taxa recorded were exotic. From the 42 new survey sites, 266 taxa were recorded (65%) with the addition 59 sites from the previous surveys a total of 378 taxa were recorded from survey plots. A further 28 taxa were recorded opportunistically.

The 407 taxa occurred in 86 families and 257 genera (Appendix). Of the exotic taxa, ten were recorded opportunistically. Several of these were only recorded once others however, were very common and at times could be considered ubiquitous for all communities. The ten most frequent and abundant exotic species found in quadrats in decreasing order of relative abundance are: *Opuntia stricta, Hypochaeris radicata, Opuntia aurantiaca, Chloris virgata, Conyza albida, Bidens pilosa, Sonchus olearceus, Stellaria media, Hyparrhenia hirta, Verbena rigida* and *Foeniculum vulgare.*

Rare or restricted plant species

There are 15 taxa considered significant within Kwiambal National Park or on adjoining lands purchased by the National Parks and Wildlife Service. Five of these taxa are listed nationally as rare or threatened (ROTAP) species (Briggs & Leigh 1996), three of which are also included within the *NSW Threatened Species Conservation Act* (1995).

Acacia williamsiana (2RCa) is a rare shrub with a disjunct distribution on the North Western Slopes of NSW, known from Torrington SRA, Kings Plains NP and Severn River NR. At Kwiambal this species was found to be very common on exposed ridges, rock outcrops and within areas dominated by Mixed Stands.

Astrotricha roddii (3VCa, listed Endangered under the TSC Act) is found in Kings Plains NP and Severn River NR in NSW and Mt Bullagang in Queensland. It was found to be widespread but scattered throughout the Park on outcrops and rocky ridge areas. Populations were also found on adjoining properties and in the neighbouring Severn SF.

Euphorbia sarcostemmoides (3KCa, listed Endangered under the TSC Act) is a poorly-known species mainly from tropical and arid Australia and has only been found in a few localities within NSW. Only one plant was seen within Mixed Stands on land that has not been included within the current Park but on land that is owned by the Service.

Olearia gravis (3KC-) is a poorly known taxon that has a disjunct and sporadic distribution from Murgon to Sundown and Girraween NP in Queensland, and Torrington SRA, Kings Plains NP and Gibraltar Range NP in NSW. Many hundreds of plants were found within Kwiambal and surrounding areas including Severn SF, particularly on rocky ridges and around outcrops. With large populations within Kwiambal, Torrington, Kings Plains, Sundown and Girraween it is suggested that a more appropriate ROTAP code for this species would be 3RCa.

Thesium australe (3VCi, listed as Vulnerable under the TSC Act) is a herb that has a widespread but sporadic distribution from Queensland to Victoria, and within the Park was found from only one locality, on Metabasalt. No *Themeda australis* was found at the locality which is often associated within this species. *Cymbopogon refractus* was the dominant grass at the site.

Ten other taxa considered to be of conservation significance include those that are disjunct or thought to be at or near their geographic limit. Many of these taxa have not until now been included within, or are poorly represented within the reserve network and add to the overall importance of Kwiambal regionally. These taxa are: *Angophora leiocarpa, Bertya oleifolia, Corymbia dolichocarpa, Eucalyptus populnea* subsp. *bimbil, Haemodorum planifolium, Parsonsia straminea, Phyllanthus carpentariae, Santalum acuminatum, Stylidium debile* var. *paniculatum* and *Zornia muriculata* subsp. *angustata. Euphorbia sarcostemmoides, Santalum acuminatum* and *Stylidium debile* var. *paniculatum* are not currently within the Park boundaries but are within land owned and controlled by the National Parks and Wildlife Service.

Conclusion

Eight distinct vegetation communities have been identified within the Kwiambal National Park. A number of these are notable due to their restricted occurrence and poorly conserved nature, in particular Mixed Stands with its 'dry rainforest' affinities. Rock type was one of the main environmental correlates associated with the delineation of communities.

Kwiambal National Park is an area that has been disturbed in the past. This is particularly so for the *Eucalyptus albens* (White Box) associated and the 'dry rainforest' influence communities. A number of rare species have been recorded including three species at present included on the *NSW Threatened Species Conservation Act* (1995).

The affinities of many of the vegetation assemblages in Kwiambal are with south central Queensland rather than most areas within New South Wales. Most of the taxa within Kwiambal are restricted to the north-east of the state and not commonly found further south.

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Appendix: Flora of Kwiambal National Park and surrounds. Based primarily on collections made during this survey with the additional records from previous surveys. Nomenclature follows that of Harden (1990–1993) except where recent changes have occurred, and authorities have been given for these species. Taxa found within the survey sites are scored according to their occurrence in each of the 8 flexible UPGMA communities defined, some taxa were found in previous surveys or opportunistically and therefore are not assigned to a specific community. C1 = Mixed Stand Woodland; C2 = Granite Woodland; C3 = Metasediment Woodland; C4 = Riverine; C5 = Metabasalt Woodland; C6 = Granite Open Woodland; C7 = Limestone Woodland; C8 = Alluvial Woodland.

*** denotes introduced taxa**

Community	No. of sites	Richness per 400 m² (average)	No. of introduced taxa	No. of taxa
C1: Mixed Stand Woodland	10	25–50 (42)	145	17
C2: Granite Woodland	8	35–55 (45)	130	16
C3: Metasediment Woodland	9	27–53 (35)	112	12
C4: Riverine	5	41–51 (46)	118	22
C5: Metabasalt Woodland	3	36–44 (42)	74	11
C6: Granite Open Woodland	4	26–31 (28)	67	2
C7: Limestone Woodland	2	31–40 (36)	52	10
C8: Alluvial Woodland	1	41	41	9

	C1	C2	C3	C4	C5	C6	C7	C8
PTERIDOPHYTES AND ALLIES								
Adiantaceae								
Adiantum aethiopicum	1						7	
Adiantum hispidulum								
Aspleniaceae								
Asplenium flabellifolium								
Pleurosorus rutifolius								
Pleurosorus subglandulosus			3	4	5			
Azollaceae								
Azolla filiculoides var. *rubra*								
Marsileaceae								
Marsilea costulifera D.L.Jones				4				
Psilotaceae								
Psilotum nudum								
Sinopteridaceae								
Cheilanthes distans	1	2	3	4	5	6		
Cheilanthes sieberi subsp. *sieberi*	1	2	3	4	5	6	7	8
Pellaea falcata var. *nana*								
GYMNOSPERMS								
Cupressaceae								
Callitris endlicheri			3		5			
Callitris glaucophylla	1	2	3	4	5	6	7	8
MONOCOTYLEDONS								
Anthericaceae								
Arthropodium milleflorum	1	2		4	5	6		8
Caesia parviflora var. *parviflora*		2	3					
Dichopogon strictus						5		
Laxmannia gracilis								

	C1	C2	C3	C4	C5	C6	C7	C8
Asphodelaceae								
Bulbine bulbosa								
Commelinaceae								
Commelina cyanea	1	2	3	4	5	6		
Murdannia graminea		2				6		
Cyperaceae								
Bulbostylis barbata								
Bulbostylis densa								
Carex incomitata	1	2		4	5			
Carex inversa			3	4	5			
Cyperus fulvus	1	2						
Cyperus gracilis	1	2	3	4	5			8
Cyperus squarrosus					5			8
Fimbristylis dichotoma		2				6		
Gahnia aspera	1							
Lepidosperma lateralte	1	2				6		
Schoenus apogon		2						
Scleria mackaviensis	1	2	3			6		
Haemodoraceae								
Haemodorum planifolium						6		
Hypoxidaceae								
Hypoxis hygrometrica								
Juncaceae								
**Juncus bufonius*				4				
Juncus ochrocoleus				4				
Juncus remotiflorus	1	2		4				
Luzula flaccida	1							
Lomandraceae								
Lomandra confertifolia					5		7	
Lomandra filiformis subsp. *filiformis*		2	3		5			
Lomandra leucocephala subsp. *leucocephala*		2		4		6		
Lomandra longifolia	1	2	3	4	5		7	
Lomandra multiflora subsp. *multiflora*	1	2	3	4				8
Luzuriagaceae								
Eustrephus latifolius	1	2		4			7	
Orchidaceae								
Cymbidium canaliculatum	1							
Pterostylis boormanii	1	2	3			6		
Pterostylis daintreana								
Phormiaceae								
Dianella caerulea var. *cinerascens*	1	2	3	4	5		7	
Dianella longifolia								
Dianella revoluta var. *vinosa*	1			4				
Stypandra glauca						6		
Tricoryne elatior								
Poaceae								
Agrostis avenacea					5			
Agrostis venusta				4				
Ancistrachne uncinulata								
Aristida jerichoensis								

	C1	C2	C3	C4	C5	C6	C7	C8
Poaceae cont.								
Aristida psamnophila								
Aristida ramosa	1	2	3	4	5	6	7	8
Aristida vagans	1	2	3	4		6		
Arundinella nepalensis	1	2		3				
Austrodanthonia bipartita (Link) H.P.Linder								
Austrodanthonia monticola (Vickery) H.P.Linder	1							
Austrostipa aristiglumis (F.Muell.) S.W.L.Jacobs & J.Everett								
Austrostipa drummondii (Steud.) S.W.L.Jacobs & J.Everett	1	2	3	4	5			
Austrostipa nitida (Summerh. & C.E.Hubb.) S.W.L.Jacobs 7 J.Everett								
Austrostipa scabra (Lindl.) S.W.L.Jacobs & J.Everett								
Austrostipa setacea (R.Br.) S.W.L.Jacobs & J.Everett								
Austrostipa verticillata (Nees ex Spreng.) S.W.L.Jacobs & J.Everett								
**Briza maxima*								
**Bromus diandrus*								
**Chloris virgata*	1	2	3		5			
Chrysopogon fallax								
Cymbopogon obtectus	1							
Cymbopogon refractus	1	2	3	4	5	6	7	
Cynodon dactylon				4				
Dichelachne micrantha								
Digitaria breviglumis	1					6		
Digitaria brownii	1							
**Digitaria ischaemum*								
**Digitaria sanguinalis*								
Echinopogon intermedius								
Echinopogon ovatus	1	2	3	4				
**Ehrharta calycina*								
Enneapogon gracilis	1		3					
Enneapogon nigricans				4				
Entolasia stricta	1	2	3	4		6		
Eragrostis elongata		2	3			6		
Eragrostis leptostachya				4				
Eulalia aurea			3					
**Hyparrhenia hirta*	1	2		4	5		7	
Imperata cylindrica				4				
**Lolium temulentum*			3					
Microlaena stipoides	1	2	3			6	7	8
Oplismenus aemulus	1	2						
**Panicum antidotale*								
Panicum effusum								
Panicum simile		2	3	4	5			
Paspalidium distichum	1		3					
**Paspalum dilatatum*								
Plinthanthesis urvillei	1			4				
Poa sieberiana var. *hirtella*								
**Setaria pumila*	1			4				
Sorghum leiocladum								
Sporobolus creber	1			4				

	C1	C2	C3	C4	C5	C6	C7	C8
Poaceae cont.								
Themeda australis (triandra)	1							
Thomandia longifolia (R.Br.) H.P.Linder		2	3			6		
Tragus australianus								
Tripogon loliiformis		2	3			6		
**Urochloa texana*								
**Vulpia bromoides*	1							
Xanthorrhoeaceae								
Xanthorrhoea johnsonii	1	2	3			6		
DICOTYLEDONS								
Anacardiaceae								
**Schinus areira*								
Acanthaceae								
Brunoniella australis			3					
Hypoestes floribunda								
Rostellularia adscendens subsp. *adscendens*								
Amaranthaceae								
Alternanthera denticulate								
**Gomphrena celosioides*								
Apiaceae								
Actinotus helianthi	1					6		
Daucus glochidiatus	1	2	3	4	5		7	8
**Foeniculum vulgare*		2	3	4			7	8
Hydrocotyle laxiflora								
Hydrocotyle peduncularis				4				
Trachymene incisa	1					6		
Apocynaceae								
Alstonia constricta	1							
Parsonsia eucalyptophylla			3	4	5			
Parsonsia lanceolata								
Parsonsia straminea							7	
Araliaceae								
Astrotricha longifolia	1							
Astrotricha roddii								
Asclepiadaceae								
**Gomphocarpus fruticosus*				4				
Marsdenia viridiflora								
Asteraceae								
**Bidens pilosa*	1	2	3	4				8
**Bidens subalternans*								
Brachyscome gracilis	1	2	3		5			
Brachyscome multifida								
Brachyscome microcarpa	1	2	3	4		6		
Calotis cuneifolia	1	2						
Calotis dentex	1	2		4		6		
Calotis hispidula	1	2			5			
Calotis lappulaceae	1	2	3	4	5		6	7
Cassinia quinquefaria	1	2	3		5			
Cassinia uncata								
Centipeda minima var. *languginosa*								
Centipeda racemosa								

	C1	C2	C3	C4	C5	C6	C7	C8
Asteraceae cont.								
Chrysocephalum apiculatum	1	2		4				
**Cirsium vulgare*				4				
**Conyza albida*	1	2	3	4	5		7	8
**Conyza bonariensis*								
**Crepis capillaris*							7	
Cymbonotus lawsonianus	1			4	5			
Euchiton involucratus (G.Forst.) Holub								
Euchiton sphaericus (Willd) Holub	1	2						8
Glossogyne tannensis	1	2	3		5	6		
**Gnaphalium coarctatum*		2		4				
**Gnaphalium polycaulon*				4				
Hyalosperma semisterile								
**Hypochaeris radicata*	1	2		4	5			
**Lactuca serriola*			3				7	
Olearia elliptica		2	3		5			
Olearia gravis	1	2						
Olearia ramosissima								
**Schkuhria pinnata* var. *abrotanoides*								
Senecio diaschides	1	2	3	4				
Senecio lautus subsp. *dissectifolius*			3					
Senecio murrayanus								
Senecio sp. E		2						
Senecio tenuiflorus								
Sigesbeckia australiensis	1	2	3	4	5			
Solenogyne bellioides			3					
**Sonchus asper* subsp. *glaucescens*	1							8
**Sonchus olearceus*	1	2	3	4	5		7	
**Taraxacum officinale*	1			4				
Triptilodiscus pygmaeus		2		4		6		
Vernonia cinerea var. *cinerea*	1	2	3		5			
Vittadinia cuneata						6		
Vittadinia dissecta var. *hirsuta*		2	3					8
Vittadinia hispidula								
Vittadinia muelleri								
Vittadinia sulcata	1	2	3	4	5			
**Xanthium spinosum*								
**Zinnia peruviana*								
Bignoniaceae								
Pandorea pandorana	1	2	3					
Boraginaceae								
**Amsinckia intermedia*								
Cynoglossum australe	1	2		4	5			8
**Myosotis intermedia*								
Brassicaceae								
Cardomine paucijuga				4	5			
**Hirschfeldia incana*								
**Lepidium bonariense*		2						
**Rapistrum rugosum*								
Cactaceae								
**Opuntia aurantiaca*	1	2	3	4	5	6		
**Opuntia stricta* var. *stricta*	1							
**Opuntia tomentosa*	1	2	3	4		6	7	

	C1	C2	C3	C4	C5	C6	C7	C8
Campanulaceae								
Wahlenbergia communis	1	2	3	4	5	6	7	
Wahlenbergia gracilenta								
Wahlenbergia gracilis								
Wahlenbergia graniticola		2	3		5			
Wahlenbergia planiflora subsp. *longipila*				4				
Wahlenbergia stricta								
Caryophyllaceae								
**Arenaria leptoclados*	1	2					7	
**Paronychia brasiliana*								
**Petrorhagia nanteuilii*							7	
Polycarpaea corymbosa var. *minor*	1	2						
**Polycarpon tetraphyllum*	1	2	3		5			8
Scleranthus biflorus						6		
**Stellaria media*	1	2		3	4			
Stellaria multiflora								
**Stellaria pallida*								
Casuarinaceae								
Casuarina cunninghamiana	1							
Chenopodiaceae								
Chenopodium carinatum	1							
Chenopodium pumilio								
Einadia hastata	1	2	3	4	5			8
Einadia polygonoides								
Einadia trigonus subsp. *stellutlata*					5			
Clusiaceae								
Hypericum gramineum	1	2	3	4		6		
Convolvulaceae								
Convolvulus erubescens								
Dichondra repens	1	2	3					
Dichondra sp. A	1	2	3	4	5	6	7	8
Evolvulus alsinoides var. *decumbens*		2	3		5	6		
Crassulaceae								
Crassula colorata var. *acuminata*		2	3			6		
**Bryophyllum delagoense*								
Dilleniaceae								
Hibbertia acicularis								
Hibbertia kaputarensis								
Hibbertia obtusifolia	1	2	3	4	5			
Droseraceae								
Drosera peltata								
Epacridaceae								
Brachyloma daphnoides subsp. *glabrum* (Blakely) J.T.Hunter								
Brachyloma daphnoides subsp. *pubescens* J.T.Hunter								
Leucopogon attenuatus								
Leucopogon muticus		2	3			6		
Melichrus erubescens								
Melichrus urceolatus	1	2	3		5	6		
Styphelia triflora		2	3					

	C1	C2	C3	C4	C5	C6	C7	C8
Euphorbiaceae								
Bertya oleifolia	1		3		5			
Beyeria viscosa								
Breynia cernua (Poir.) Muel.Arg.	1	2						
Chamaesyce drummondii	1	2	3		5			8
Euphorbia Eremophila		1						
Euphorbia planticola								
Euphorbia sarcostemmoides								
Petalostigma pubescens	1							
Phyllanthus carpentariae Muell.Arg.	1					6		
Phyllanthus virgatus	1	2	3	4		6		
Poranthera microphylla		2	3			6		
Fabaceae								
Acacia cheelii	1					6		8
Acacia decora								
Acacia farnesiana								
Acacia leiocalyx	1	2	3	4		6		
Acacia leptoclada						6		
Acacia neriifolia		2						
Acacia pruinosa	1	2						
Acacia williamsiana J.T.Hunter	1					6		
Crotalaria mitchellii subsp. *mitchellii*		1						
Cullen tenax				4				
Desmodium brachypodum	1	2	3		5	6	7	
Desmodium varians	1	2	3	4	5	6	7	8
Glycine clandestina	1	2	3	4			7	
Glycine latifolia							7	
Glycine tabacina							7	
Glycine tomentella	1	2	3	4	5		7	
**Hirschfeldia incana*								
Hovea lanceolata				4				
Hovea linearis	1	2	3	4		6		
Indigophora adesmiifolia								
Jacksonia scoparia		2						
Lespedeza juncea subsp. *sericea*	1							
Lotus australis		2						
Medicago polymorpha				4	5		7	8
**Melilotus indicus*			3					
Mirbelia pungens								
Pultenaea flexilis								
Pultenaea foliolosa								
Rhychosia minima								
Senna barklayana								
Swainsona cadellii								
Swainsona galegifolia				4	5			
Swainsona luteola								
Swainsona queenslandica			3				7	8
Swainsona sericea	1	2						
**Trifolium arvense*				4	5			
**Trifolium dubium*								
**Trifolium campestre*				4	5			
**Trifolium repens*				4				
Zornia dyctiocarpa var. *dyctiocarpa*	1	2	3					
Zornia dyctiocarpa var. *angustata*								
Geraniaceae								
**Geranium molle* var. *molle*								
Geranium solanderi var. *solanderi*			3	4			7	8

	C1	C2	C3	C4	C5	C6	C7	C8
Goodeniaceae								
Goodenia bellidifolia		2	3			6		
Goodenia glabra		2						
Goodenia hederacea subsp. *hederacea*	1		3			6		
Dampiera stricta								
Haloragaceae								
Gonocarpus elatus								
Gonocarpus tetragynus								
Haloragis glauca forma *glauca*	1							
Haloragis heterophylla		2		4				
Lamiaceae								
Ajuga australis	1		3	4	5			
Mentha diemenica				4	5			8
Mentha satureioides				4				8
Plectranthus parviflorus	1					6		
Prostanthera saxicola	1							
Scutellaria humilis	1							
Westringia longifolia								
Lobeliaceae								
Isotoma axillaris								
Isotoma fluviatilis subsp. *borealis*								
Lobelia gracilis						6		
Pratia purpurascens				4				
Loganiaceae								
Logania albiflora								
Loranthaceae								
Amyema miquelii								
Dendrophthoe glabrescens	1							
Muellerina bidwillii								
Muellerina eucalyptoides		2	3					
Malaceae								
**Malus x domestica*								
Malvaceae								
Abutilon oxycarpum	1							
**Malvastrum americanum*								8
**Pavonia hastata*			3	4				
Sida cunninghamii								
Sida filiformis								
**Sida rhombifolia*				4				
Sida ?spinosa								
Moraceae								
Ficus rubiginosa	1							
**Maclura pomifera*				4				
Myoporaceae								
Eremophila debilis			3		5		7	
Eremophila deserti							7	
Myoporum montanum								
Myrtaceae								
Angophora floribunda		2		4			7	
Angophora leiocarpa	1							
Callistemon citrinus								
Callistemon viminalis	1							

	C1	C2	C3	C4	C5	C6	C7	C8
Myrtaceae cont.								
Calytrix tetragona		2	3			6		
Corymbia dolichocarpa (D.J.Carr & S.G.M.Carr) K.D.Hill & L.A.S.Johnson	1							
Eucalyptus albens			3				7	
Eucalyptus blakelyi				4				8
Eucalyptus caleyi subsp. *caleyi*	1							
Eucalyptus camaldulensis				4				
Eucalyptus dealbata	1	2	3			7		
Eucalyptus melanophloia	1	2	3	4	5	6	7	
Eucalyptus melliodora								8
Eucalyptus populnea subsp. *bimbill*	1							
Leptospermum brachyandrum	1							
Leptospermum brevipes	1	2	3	4		6		
Nyctaginaceae								
Boerhavia dominii	1	2	3					
Olacaceae								
Olax stricta								
Oleaceae								
Jasminum lineare	1		3	4	5			
Jasminum sauvissimum			3					
Notelaea microcarpa var. *microcarpa*	1	2	3	4	5		7	8
Onagraceae								
**Oenothera rosea*				4				
Oxalidaceae								
Oxalis chnoodes	1		3					
Oxalis perennans	1	2	3	4	5		7	8
Phytolaccaceae								
**Phytolacca octandra*								
Pittosporaceae								
Pittosporum phylliraeoides								
Rhytidosporum procumbens								
Plantaginaceae								
Plantago varia	1	2	3	4	5			
Polygalaceae								
Polygala linariifolia								
Polygonaceae								
Persicaria decipiens								
Rumex brownii	1		3	4	5			
Portulacaceae								
Anocampseros australiana								
Calandrinia eremaea			3					8
Portulaca bicolor var. *rosea*	1							
Portulaca filifolia	1					7		
Portulaca oleracea								
Primulaceae								
**Anagallis arvensis*		2		4				8

	C1	C2	C3	C4	C5	C6	C7	C8
Proteaceae								
Grevillea ramosissima								
Persoonia sericea								
Ranunculaceae								
Clematis glycinoides				4			7	
Ranunculus lappaceus		2		4	5			8
Ranunuculus sessiliflorus	1			4	5			
Rhamnaceae								
Alphitonia excelsa	1	2	3			6		
Cryptandra amara var. *floribunda*						6		
Pomaderris andromedifolia								
Rosaceae								
Rubus parvifolius							7	
**Rubus rubiginosa*								
Rubiaceae								
Asperula conferta				4			7	
Asperula subulifolia								
Canthium odoratum	1	2	3			6	7	
Canthium oleifolium								
Galium gaudichaudii	1	2	3		5			
Galium migrans	1	2			5			
Opercularia diphylla								
Opercularia hispida								
Rutaceae								
Correa reflexa var. *reflexa*	1	2						
Geijera parviflora								
Philotheca myoporoides subsp. *conduplicatus* (Paul G. Wilson) M.J.Bayly								
Zieria fraseri								
Santalaceae								
Santalum acuminatum								
Santalum lanceolatum	1							
Thesium australe					5			
Sapindaceae								
Alectryon subdentatus forma *subdentatus*								
Dodonaea sinuolata subsp. *sinuolata*								
Dodonaea viscosa var. *angustifolia*	1		3					
Dodonaea viscosa var. *mucronata*								
Scrophulariaceae								
Gratiola peruviana								
Stemodia glabella	1		3				7	8
**Verbascum thapsus* subsp. *thapsus*								
Veronica calycina	1	2		4			7	8
Simaroubaceae								
**Ailanthus altissima*								
Solanaceae								
Datura stamonium								
Solanum americanum				4				
Solanum brownii		2	3		5			
Solanum cinereum			3				7	

	C1	C2	C3	C4	C5	C6	C7	C8
Solanaceae cont.								
Solanum coactiliferum								
Solanum cleistogamum								
**Solanum nigrum*								
Stackhousiaceae								
Stackhousia muricata		2	3					
Stackhousia viminea				4				
Sterculiaceae								
Brachychiton populneus	1	2	3	4		7	8	9
Rulingia dasyphylla			3					
Stylidiaceae								
Stylidium debile var. *paniculatum*	1							
Stylidium eglandulosum								
Stylidium graminifolium				4				
Stylidium laricifolium	1					6		
Thymeliaceae								
Pimelea curviflora subsp. *divergens*								
Pimelea néo-anglica		2			5		7	
Pimelea stricta								
Pimelea strigosa								
Urticaceae								
Urtica incisa			3	4				
Verbenaceae								
**Verbena rigida*				4				8
**Verbena aristigera*								
Violaceae								
Hybanthus monopetalus	1					6		
Viola betonicifolia								

SHORT COMMUNICATION

Confirmation of *Sarcochilus dilatatus* F. Muell. (Orchidaceae) in New South Wales, and an extension in range.

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Introduction

The species *Sarcochilus dilatatus* F. Muell. is an Australian endemic orchid, recorded in south-eastern Queensland and the upper north-east of New South Wales (NSW), between the Kroombit Tops (Calliope Range — inland from Gladstone) Queensland (Walsh 1997) and the Richmond River New South Wales (Jones 1988). The species occurs along the coast and lower ranges, up to 400 m altitude (Weston 1993) where it is epiphytic. It appears to favour *Araucaria cunninghamii* (Hoop Pine) above all other hosts, and germinates on smaller stems about 8–12 mm diameter, which are in the higher, brighter parts of the crown. The largest population of the species I have seen, south-west of Bundaberg, Queensland, was within a plantation of Hoop Pine, a 'habitat' which Walsh (1997) also considers extremely rich in this otherwise rare species.

Identification of *Sarcochilus dilatatus* requires flowers for confirmation, although the foliage is also quite distinctively marked. A net-like pattern of reddish rectangles occurs across the foliage, with a background colour of green. Often this network pattern is only visible when light is transmitted through the foliage. Leaves on most individuals are few, falcate, and borne on a short stem. The roots are long and slender, mainly white, although older roots will be grey. The inflorescences are axillary, generally pendent, and mostly only one is produced from each axil at any one time, although the axil may produce a number of inflorescences in successive years. Older, larger plants may have a number of inflorescences concurrently (the confirmation specimen was carrying three racemes), but the most common situation is for only one or two racemes per plant. The flowers are small, star-shaped, mainly brown or brown-marked on a greenish background, and have a white labellum variously marked with orange. The tepals are distinctly spathulate.

Conservation status

Sarcochilus dilatatus has a national ROTAP code of 3RC- (Briggs & Leigh 1996), that is the species is considered rare (R), has a range in excess of 100 kilometres (3) and is conserved (C), although the adequacy of conservation is not determined (-). The species is listed as conserved only in Lamington National Park, Queensland, but the status of that population is uncertain. Although recorded from NSW, it has been considered extinct in that state.

Prior to this survey the only collection from NSW is listed as being collected in late September 1894 from a locality near Lismore (NPWS 1998). Although listed in Weston (1993), Jones (1988) and Bishop (1996) as flowering in September and October, the slides and records of the species held by the author suggest flowering in December, January or February. Walsh (1997) supports these observations, noting that the southern populations (south from Bundaberg) flower from November to January, while the northern populations (Calliope Range) flower in August and September. Bishop (1994) explains that the specimen collected in Lismore is not of very good quality, and identification is difficult, going on to suggest that the identification may be in error and the material is actually of the closely related *Sarcochilus australis*, which is close to its northern limit in that area (Currell 1993). The specimen collected in 1894 is not a flowering specimen (P. Weston pers. comm.).

Results

The author was undertaking surveys of Crown lands of the Clarence-Moreton Basin to assess the status of orchid populations. This information was to assist in decision making and management processes for lands, which in large part are managed by the Rural Lands Protection Boards, NSW National Parks and Wildlife Service, State Forests of NSW or the NSW Department of Land and Water Conservation.

Preliminary assessments in the Nymboida area had commenced in early October. A number of taxa had been collected for identification from the fallen crown of a Hoop Pine. One of the plants was a small *Sarcochilus* (or related) species with mottled and falcate foliage. However, insects had damaged the immature inflorescences, and fresh material (with intact inflorescences) was sought at the site of the original collection.

During the second visit to the site in early January 1999, a number of other plants were located, including one in flower. A photograph of the plant was identified as *Sarcochilus dilatatus* and later confirmed by Peter Weston at the Royal Botanic Gardens Sydney. The species is therefore extant in NSW and much further south than the original collection. The population is growing on Hoop Pine and associated trees in a small patch of rainforest surrounded by grassy dry sclerophyll forest. It is intended that further surveys will be undertaken to assess the extent of the population.

As a result of the current find, the conservation status needs to be revised and the extinct rating for zone 56 (North Coast NSW) should be removed. An uncertain rating for the conservation status of the New South Wales populations is suggested until further assessment of the distribution and abundance of populations is conducted. There is a case to have the species listed in Schedule 2 (vulnerable) of the *NSW Threatened Species Conservation Act* 1995 on the basis that the species is known from only a single population in New South Wales and that it is potentially threatened by collecting, fire and changes to land use.

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SHORT COMMUNICATION

Bothriochloa biloba (Poaceae) in natural grasslands on slopes of the Liverpool Plains, New South Wales

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Introduction

The grass *Bothriochloa biloba* S.T. Blake is listed in Schedule 2 of the *NSW Threatened Species Conservation Act* (1995) as a Vulnerable species. In the national ROTAP listing (Briggs & Leigh 1996) it is also given Vulnerable status with Risk Code of 3V (geographic range in Australia > 100 km). As a vulnerable taxon the species is regarded as at risk, over a period of 20 to 50 years, of disappearing from the wild through continuous depletion, or likely change in land use which would threaten its survival.

Yu et al. (1997) found that, compared to *Bothriochloa macra*, *Bothriochloa biloba* has abnormal embryology with greater apomictic development and degeneration at various stages of development. Based on more detailed work, Yu (pers. comm.) concludes that apomixis markedly reduces seed production in *Bothriochloa biloba*.

Data on the occurrence of *Bothriochloa biloba* in a range of grassland associations on slopes in the Garrawillie Creek sub-catchment of the Liverpool Plains, New South Wales are presented here. Sites were selected on two contrasting rock types and two aspects, providing the opportunity to delineate preferences of the species. All sites had been grazed over many decades by domestic and native herbivores, and the topography and rocky nature of the slopes had prevented soil disturbance by humans. Thus the data are relevant to defining the effect of grazing on maintenance of the species.

Methods

Sixteen sampling sites were selected in natural grasslands on the slopes of the Garrawillie Creek sub-catchment at the western margin of the Liverpool Plains. The sites were chosen to represent contrasting lithological types and aspects, no known history of cropping, and as high a degree of structural and floristic homogeneity as possible. Eight sites were on terraced slopes formed from basaltic rocks of the Garrawilla Volcanics, and eight were on scree slopes at the base of domes of phonolite (Bean 1974). The latter is a magnesium-, iron-, calcium-poor, sodium-, potassium-rich rock producing a light-textured soil. On each rock type half the sites were on NW slopes and half on SE slopes. Latitude, longitude, rock type, aspect, altitude and general comments at each site are listed in Table 1.

Table 1 Sites at which *Bothriochloa biloba* occurred.

Site no.	Latitude/ longitude	Distinctive species of grassland association	Rock type	Aspect	Altitude (m asl)	Comments
11	31°12'18'' 149°46'49''	*Aristida ramosa*	Garrawilla Volcanics	NW	440	Site on gentle slope of top portion of terrace & steeper front of terrace
10	31°12'02'' 149°46'43''	*Bothriochloa macra/ decipiens*	Garrawilla Volcanics	SE	435	Site on steep slope with large boulders ≥ 0.5 m embedded in the soil
12	31°12'10'' 149°46'40''	*Bothriochloa macra/ decipiens*	Garrawilla Volcanics	NW	430	Site on gentle slope on top portion of terrace & steeper front of terrace; scattered rock fragments (av. diam. 15 cm) to prominent boulders embedded in the soil
13	31°12'15'' 149°46'44''	*Bothriochloa macra/ decipiens*	Garrawilla Volcanics	SE	430	Site mainly on steep front of terrace; scattered rock fragments (av. diam. 15 cm) to prominent boulders embedded in soil
14	31°12'23'' 149°45'23''	*Dichanthium sericeum*	Garrawilla Volcanics	NW	420	Site on very gentle slope on top of terrace; scattered small rock fragments av. 10 cm diameter
15	31°12'37'' 149°45'32''	*Dichanthium sericeum*	Garrawilla Volcanics	SE	410	Site on almost flat top of terrace; small very minor rock fragments and deeply cracked soil
16	31°12'15" 149°44'37"	*Stipa aristiglumis*	Garrawilla Volcanics	SE	380	Site on front of upper terrace & very gentle slope of top portion of lower terrace
6	31°13'10'' 149°46'36''	*Dichanthium sericeum*	phonolite scree	SE	450	Site on even 15–16° slope; scattered small fragments & larger boulders embedded in soil

Sampling was carried out from late January to the end of April 1996. Species composition and abundance (frequency) were determined using a compound series of variable-sized concentric subquadrats (Outhred 1984). At sampling sites on the phonolite scree, 8 subquadrats with areas of 2, 4, 8, 16, 32, 64, 128 and 256 square metres were established using one central iron stake and 4 diagonal cords leading outwards to 4 stakes at the corners of the quadrat. The limits of each subquadrat

within the quadrat were defined by markers attached to the diagonal cords. At sampling sites on the Garrawilla Volcanics, ten subquadrats with areas of 2, 4, 8, 16, 32, 64, 128, 256, 512 and 1024 square metres were established.

Frequency and importance scores (Outhred 1984) were calculated for 116 species. The frequency score indicates the total number of nested subquadrats in which a particular species occurred. The importance score was determined by searching each subquadrat consecutively, starting with the central smallest subquadrat and proceeding to the largest. Each species was given the score associated with the subquadrat in which it was first found. The smallest subquadrat (2 square metres) was given the highest score (equal to the number of subquadrats at each site; eight for the eight sites on phonolite scree and ten for the eight sites on Garrawilla Volcanics) and the largest subquadrat was given a score of 1. The frequency scores were subjected to cluster analyses using PATN (Belbin 1991).

Results

Of the seven grassland associations indicated by the cluster analyses (Bean 1996), five included plants of *Bothriochloa biloba*. Only the *Sporobulus creber* and *Eriochloa pseudoacrotricha* associations, which were restricted to light-textured soils on the phonolite scree, did not include plants of *Bothriochloa biloba*. Table 1 lists the grassland association at each of the eight sites in which the species was identified, and Table 2 lists the frequency and importance scores of *Bothriochloa biloba* with total number of species, and numbers of native, exotic, perennial and annual species at the same sites. The grassland sampled at site 16, with its high proportion of exotic and annual species, was assessed as a community with a high level of disturbance.

Table 2. Frequency (FS) and importance (IS) scores of *Bothriochloa biloba*, total number of species, and numbers of native, exotic, perennial and annual species for the eight sites at which *Bothriochloa biloba* occurred. The scores for site no. 6 are out of 8 and for the other sites out of 10. Available plant material for some individual plants was inadequate to allow identification to species level; thus the total number of species listed for some sites is higher than the sum of the number of natives plus exotics and/or the number of perennials plus annuals.

Site No.	FS	IS	Total no. species	No. of natives	No. of exotics	No. of perennials	No. of Annuals
11	5	7	39	31	7	27	6
10	2	5	42	30	11	30	6
12	3	3	47	37	9	36	5
13	1	1	36	31	4	31	2
14	5	5	44	31	12	29	9
15	7	8	33	24	9	21	7
16	1	1	40	17	22	16	15
6	1	3	45	36	8	32	6

Bothriochloa biloba showed a distinct preference for the heavier-textured soils formed from the Garrawilla Volcanics. Of eight sites on these soils, seven included *Bothriochloa biloba*. The one site in which *Bothriochloa biloba* was not identified was an *Aristida ramosa* association site. This site was characterised by rank growth of *Aristida ramosa*, Wire Grass, and a low total number of species (33). Abundant *Tribulus terrestris*, with its hard sharp-pointed burrs detrimental to the mouths, intestines (Cunningham et al. 1981) and feet of grazing animals, was assessed as the main reason for almost total lack of grazing at this site. The low number of native perennial species at this site correlated with the rank growth of *Aristida ramosa* which had developed under the restricted grazing (Dadd et al. 1989).

In contrast, of the eight sites on the light-textured soils of the phonolite scree, only one included *Bothriochloa biloba* at frequency and importance scores of only 1. In the Garrawillie Creek sub-catchment, the most abundant *Bothriochloa biloba* occurs on the low-lying alluvial flats of the sub-catchment. It is concluded that the preference of *Bothriochloa biloba* for heavier-textured soils is inherent in the species and not the result of grazing out of the species from grasslands on the light-textured soils.

No preference for a particular aspect, altitude or microhabitat was evident. At all sites the *Bothriochloa biloba* plants were taller and displayed coarser culms than plants of the associated *Bothriochloa macra*, *Bothriochloa decipiens* and *Dichanthium sericeum*.

All sampling sites had, for many decades, been located within paddocks subject to grazing by both domestic and native animals. In addition to grazing, sites 12, 13 and 16 were located within paddocks, the lower portions of which had also been cropped for at least 30 years. Even though many of the paddocks were carrying stock at the time of sampling, there was no visual evidence of grazing of individual plants of *Bothriochloa biloba*. Graziers in the area have also observed that, if other grasses are available, stock do not graze plants of *Bothriochloa biloba*; grazing animals appear to selectively leave material of the coarser *Bothriochloa biloba* plants.

Outside the study area, along sections of the Oxley Highway east of Mullaley, and on the stock route running from 'Lambrook' (latitude 31°06'16", longitude 149°56'20") towards Curlewis, *Bothriochloa biloba* is a dominant species. These areas on heavier-textured soils are at the lower altitude of 300–340 m asl. In the parking area adjacent to the Mullaley Anglican church, an area which is regularly mown, *Bothriochloa biloba* is a significant species. Areas on properties that have been slashed to remove weeds also continue to contain the species.

Conclusions

This work indicates that *Bothriochloa biloba* shows a strong preference for heavier-textured soils. On these soils the species, despite its known poor seed production, has been maintained under grazing over long periods of time. It is concluded that normal levels of grazing do not lead to elimination of *Bothriochloa biloba*, and in fact may enhance maintenance of the species. By contrast, at restricted levels of grazing, rank growth of *Aristida ramosa* causes reduction in total number of species and exclusion of

Bothriochloa biloba. In grasslands grazed at an unrestricted level, stock selectively grazed other species of grass, giving *Bothriochloa biloba* a competitive advantage. Mowing and/or slashing also appeared to maintain the species.

It would be interesting, if further work could be carried out at the sites used in this study, to test whether *Bothriochloa biloba* is a native grass species favoured by normal levels of grazing similar to *Bothriochloa macra* (Prober & Thiele 1995). Further work is required to assess the effect of soil disturbance and fire on *Bothriochloa biloba*.

It is concluded that *Bothriochloa biloba* would be most effectively maintained in grasslands on heavier-textured soils under normal levels of grazing. Thus it would not be constructive to set up a Conservation Reserve of even category IV (Habitat/Species Management Area) to include the species. It is unlikely that any management practice could be devised to encourage *Bothriochloa biloba* to appear or increase on light-textured soils.

Acknowledgements

Landowners whose properties were used as sampling sites are thanked for their agreement to and interest in the carrying out of the work. The assistance of Associate Professor R.D.B. Whalley, and other members of staff of the Department of Botany of the University of New England, is gratefully acknowledged. D. Beckers of NPWS and an unnamed referee are thanked for helpful comments on the manuscript.

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SHORT COMMUNICATION

Notes on the distribution and conservation status of *Eucalyptus cannonii* R.T. Baker

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Introduction

The first collections of *Eucalyptus cannonii* were made by R.T. Baker in 1892, during collecting trips to the Rylstone and Goulburn River areas. Although Baker (1896) made numerous notes on many of the plants collected at that time, he made no remarks on the variation in *Eucalyptus macrorhyncha* (which then included *Eucalyptus cannonii*) despite claiming so in his later description of the taxon (Baker 1919).

Recognition of the variation shown in what was to become *Eucalyptus cannonii* was given by Maiden (1907) in his *Critical Revision of the Genus Eucalyptus* (as *Eucalyptus macrorhyncha* 'grandiflora' form). Maiden highlighted the collections made by Baker from Rylstone and Mt Vincent as being coarser in form with a very prominent rim.

Baker (1919) described this taxon as *Eucalyptus cannonii*, named after Herbarium assistant Mr D. Cannon. Despite Maiden's comments, Baker (1919) indicated that data presented to him by Mr G. Harris (collector of the material cited by Baker) convinced him of the distinctiveness of the taxon. *Eucalyptus cannonii* was separated from *Eucalyptus macrorhyncha* on the shape of the fruit, buds, inflorescence and features of the timber and bark.

Penfold and Willis (1961) considered *Eucalyptus cannonii* to be distinctive local race of *E. macrorhyncha* and Johnson and Blaxell (1973) reduced *E. cannonii* to a subspecies of *E. macrorhyncha*, based on the intergradation where their ranges overlap. Hill (1991) retained specific status for *Eucalyptus cannonii*.

Distinguishing features

Eucalyptus cannonii is distinguished from *Eucalyptus macrorhyncha* by the by its fewer-flowered umbels (3–7 as opposed to 7–11), shorter pedicels (1–4 mm as opposed to 2–8 mm), the usually larger distinctly angular buds and the usually larger fruits with a distinct and prominent medial rim (Fig. 1). In his original description Baker (1919) also mentions wood characteristics such as a shorter grain, longer lasting in the ground, does not turn freely and straighter in grain. These wood characteristics do not appear to have been tested since Baker's notes.

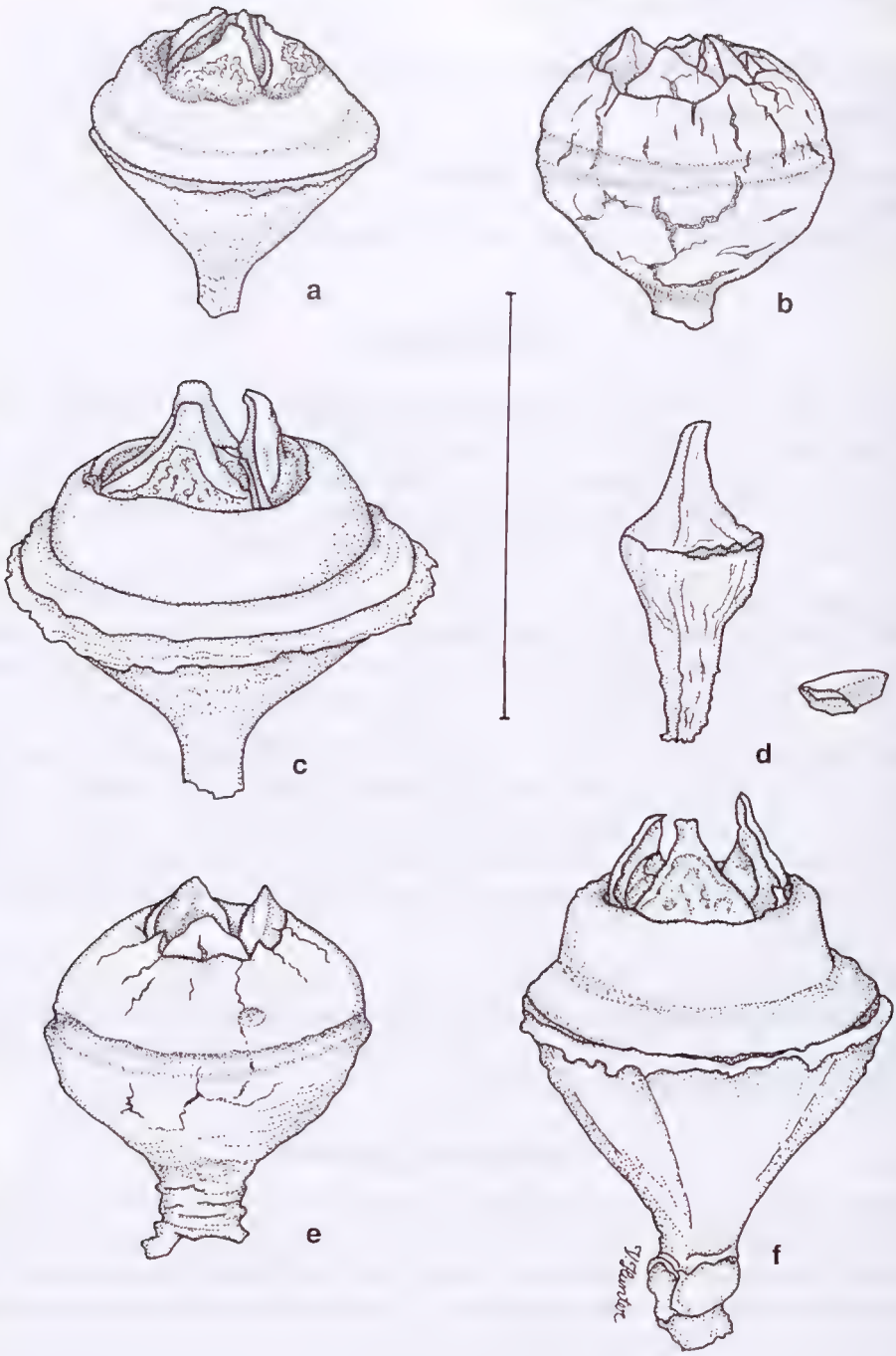

Fig. 1. Variation in *Eucalyptus cannonii* and *E. macrorhyncha*. **a,** collection of *E. cannonii* from Eskdale Gulf, Winburndale Nature Reserve. **b,** *E. macrorhyncha* from Eskdale Gulf. **c,** *E. cannonii* fruit (left) and **d,** bud (right) from Palmers Link Road, Winburndale Nature Reserve. **e,** *E. macrorhyncha* from Palmers Link Rd. **f,** *E. cannonii* from Pearsons Lookout near Capertee, one of the most frequently collected localities. Scale Bar = 1 cm. Illustrations by Vanessa Hunter.

Habitat

There appears to be no predictable habitat preferences for *Eucalyptus cannonii*. Evidence indicates wide tolerance of different conditions, with parent rock including: sandstone, shale, basalt, trachyte, claystone, and coarse conglomerates. Often this taxon is found higher on mountains and ridge tops with rocky soils such as talus slopes, cliffs, summits and spires, but it occurs also lower within valleys and on low undulating hills.

The associated taxa include *Eucalyptus blakelyi, Eucalyptus melliodora, Eucalyptus bridgesiana, Eucalyptus dalrympleana* and *Eucalyptus viminalis* on lower slopes. On rockier higher areas associates include *Eucalyptus mannifera* subsp. *praecox, Eucalyptus laevopinea, Eucalyptus polyanthemos, Eucalyptus oblonga, Eucalyptus rossii, Eucalyptus sparsifolia, Eucalyptus dives, Eucalyptus goniocalyx* and *Angophora intermedia*.

Distribution

Eucalyptus cannonii occurs from east of Mudgee to east of Bathurst for 100 km in length and 60 km in width within the Central Tablelands and Central Western Slopes of New South Wales (Fig. 2). Considering putative hybrids the distribution of the taxon can be increased by c. 10 km to the north (110 km in total). At least 30 discernable populations are known (Fig. 2). Although most populations are in remnants, most of these are in areas unlikely to be cleared en masse in the near future. Populations are reserved within Wollemi and Gardens of Stone National Parks and Winburndale Nature Reserve. On a conservative estimate there are at least 6000 individuals within Winburndale Nature Reserve alone (Hunter 1998), and the total population must be well in excess of 10 000 individuals across the range of the species. Collections have been made from some localities over the last 100 years.

Putative hybridisation

Hybridisation between species of *Eucalyptus* was recognised by some of the earliest collectors. Griffin et al. (1988) reviewed hybridisation in *Eucalyptus* and found that 55% of described taxa were known to form hybrids. Geographic proximity was the overriding important feature. Hybrids and putative introgression are consistently reported in population surveys within the genus (Potts & Wiltshire 1997). A large number of putative hybrids have been recognised with *Eucalyptus cannonii*, all of which have been with sympatric taxa, particularly *Eucalyptus macrorhyncha* but also with *Eucalyptus sparsifolia* and *Eucalyptus tenella*. It appears from the field survey (Hunter 1998) that *Eucalyptus cannonii* does freely hybridise and in many instances forms swarms and introgression zones particularly with *Eucalyptus macrorhyncha*.

Present and past threats

Notes from early collections (Australian National Herbarium, NSW National Herbarium) and publications (Anderson 1947, Blakely 1955, Penfold & Willis 1961) indicate that early this century this species was considered rare. Subsequent collector's notes suggest that in several localities *Eucalyptus cannonii* is locally frequent, if not a

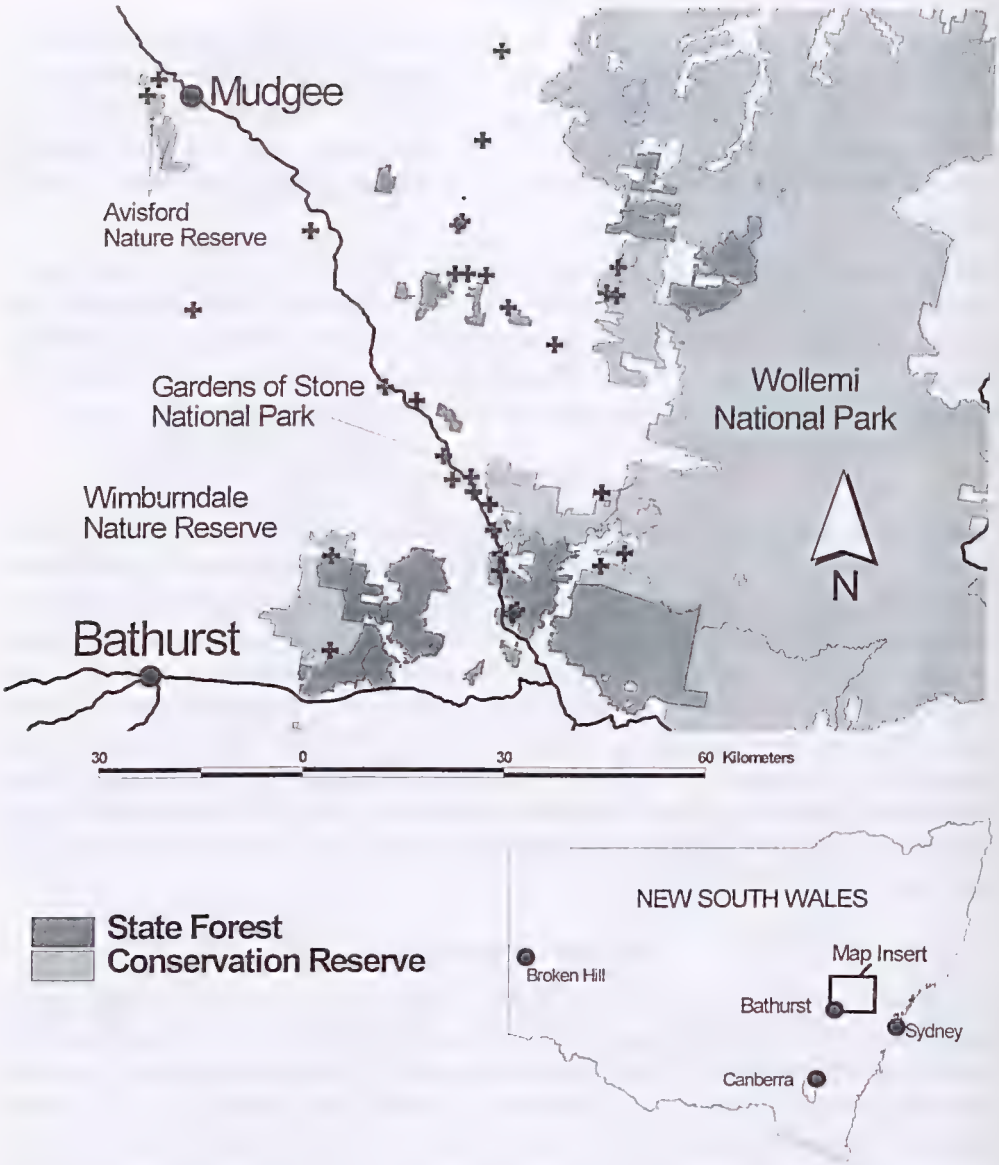

Fig. 2. Distribution of *Eucalyptus cannonii* based on all known records from the Australian National Herbarium and the New South Wales National Herbarium. + represents known populations.

dominant or co-dominant. It is likely that this taxon was locally frequent but rare and disjunct across its distribution prior to European settlement but that contraction and extinction of populations have occurred since settlement of the Rylstone and Capertee districts. The large areas of cleared agricultural land and the large scale *Pinus radiata* plantations are probably some of the more significant recent historical threats. Changes in fire regimes are unlikely to have caused any major negative changes in

populations as collections can still be made from all historical herbarium collection localities despite probable alterations to fire intensities and frequencies.

Throughout the species' distribution, clearing of land is probably the greatest risk to extant stands along with the suite of genetic and stochastic (i.e. disease) threats associated with the persistence of small isolated populations.

Conservation status

Currently *Eucalyptus cannonii* is listed as a Vulnerable species under Schedule 2 of the NSW *Threatened Species Conservation Act* 1995. It is also listed under Schedule 1 part 2 of the Federal *Endangered Species Protection Act* 1992 under 'Species which are Vulnerable' and listed as a ROTAP coded 2VCi.

It is likely that *Eucalyptus cannonii* was rare prior to European settlement (Anderson 1947, Blakely 1955, Penfold & Willis 1961), and contraction has been caused by land clearing for agriculture. The taxon is conserved within three NSW National Parks and Wildlife Service reserves. As the minimum population within Winburndale Nature Reserve is at least 6000 individuals (Hunter 1998), and populations exist in Wollemi and Gardens of Stone National Parks, we consider that the species is adequately conserved. Most other present day localities are on rocky hillsides unlikely to be cleared for agricultural purposes. The *TSC Act* (1995) requires that a taxon is eligible for listing as vulnerable, if in the opinion of the Scientific Committee the taxon is likely to become endangered unless the circumstances threatening the taxon cease. The main threatening process in regards to this species is clearing for agricultural purposes. We consider that listing as a vulnerable species (Schedule 2) under the *TSC Act* (1995) is no longer appropriate due to the variation and size of populations within the current reserve network and the number of populations within non-productive lands in private ownership. Clearing can no longer be regarded as a process that may cause this species to become endangered.

Using the ROTAP scale (Briggs & Leigh 1996) the taxon is most appropriately categorised as 2RCa, until the size of all populations is known. The distribution category of 2 (known from less than 100 km) is retained, if only the distribution of non putative hybrids are considered, the species distribution is only just 100 km in length.

Acknowledgements

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SHORT COMMUNICATION

Range extensions and conservation status of 18 restricted plant species in north-eastern New South Wales

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Introduction

During recent surveys within north-eastern New South Wales new records of range extensions for some significant plant taxa were recorded. The implications for the conservation status of each taxon in terms of their ROTAP status (Briggs & Leigh 1996) are discussed. It is important that management decisions concerning rare taxa are made using the most up-to-date information possible, hence the need to report new distributions and suggest changes in conservation status. Vouchers of all taxa discussed have been lodged at the NCW Beadle Herbarium at the Division of Botany, University of New England and/or at the Herbarium of the North Coast Regional Botanic Garden, Coffs Harbour. In the following notes National Park is abbreviated to NP and Nature Reserve to NR.

1. *Acacia barringtonensis* Tindale (family Fabaceae)

Previously believed to be restricted to a few disjunct localities in the Barrington Tops, Backwater, Boonoo Boonoo and Gibraltar Range areas but recently discovered in the east of Oxley Wild Rivers NP and in Carrai NP (P. Richards pers. comm. 1997), and along the Racecourse Trail in Werrikimbe NP (Copeland 1999). The current ROTAP code, 3RCa (Briggs & Leigh 1996) is considered adequate.

2. *Acacia macnuttiana* Maiden & Blakely (family Fabaceae)

Previously recorded from Pindari Dam area near Ashford (North Western Slopes) to Boonoo Boonoo Falls (Northern Tablelands). Populations are known from Boonoo Boonoo NP and the Torrington State Recreation Area (Clarke et al. 1998) where at least 1000 individuals occur in several populations. An unreserved population was also found in the Eagle Creek area west of Tenterfield (Hunter & Clarke 1998) and a small population has been recently discovered in the Washpool NP western additions along Morven Creek (Hunter 1998). In all localities, this species is primarily restricted to riparian situations.

Although additional populations have been found, many individuals were destroyed by the enlargement of the Pindari Dam. This taxon should still be considered vulnerable as it is a relatively short-lived obligate seeder that requires a comparatively large meta-population size to maintain viability. Its range exceeds 100 km — therefore a more appropriate ROTAP code is 3VCa.

3. *Acacia orites* Pedley (family Fabaceae)

Rare species known from Springbrook in Queensland to Demon NR in NSW (Hunter et al. 1999). Populations reserved in Nightcap, Mount Warning and Border Ranges NPs, Demon and Numinbah NRs and Mount Nothofagus and Minyon Falls Flora Reserves.

Recently populations have been found within the Washpool NP western additions on the margins of closed forests (Hunter 1998). These populations, while not extensive, are not uncommon and have extended the known southern distribution. Populations are now known from over 100 km in distribution and numbers are well in excess of 1000 individuals in the current reserve network — a ROTAP code of 3RCa is considered appropriate.

4. *Acacia pubifolia* Pedley (family Fabaceae)

Vulnerable species restricted to a small population along the Gulf Road north of Emmaville and a larger, more widespread population in the Stanthorpe–Wallangarra area (including Girraween NP), Queensland. Listed as 2VC- (Briggs & Leigh 1996) and Endangered under Schedule 1 of the *NSW Threatened Species Conservation Act* 1995.

A recent discovery of a small population on private property 4 km east of Warrabah NP represents a southerly range extension of nearly 200 km. This population of 95 plants (P. Metcalfe pers. comm. 1999) occurs in partially cleared country. The population has now been fenced off under an agreement with the landholder. A ROTAP code of 3VC- is considered more appropriate.

5. *Acacia tessellata* Tindale & Kodela (family Fabaceae)

Occurs along the eastern escarpment of the northeast of NSW, reserved within New England, Werrikimbe and Willi Willi NPs.

Recently, populations within the Washpool NP western additions have been found (Hunter 1998), extending the current distribution range to nearly 200 km. Listed as 2RC- (Briggs & Leigh 1996), with the new northern extension of range a ROTAP code of 3RCa is considered more appropriate.

6. *Callistemon pungens* P.F. Lumley & R.D. Spencer (family Myrtaceae)

Known from a number of scattered localities on the Northern Tablelands and North-Western Slopes but not known in any reserved areas, coded 3R (Briggs & Leigh 1996). A number of significant populations have recently been found in granitic areas west of the Great Dividing Range in conservation reserves — Warrabah and Kings Plains NPs, Severn River and Ironbark NRs and Torrington State Recreation Area. Also known from Oxley Wild Rivers NP (Copeland 1997), Mann River NR (Sherringham & Westaway 1995) and Single NP. Habitats range from riparian areas dominated by *Casuarina cunninghamiana* subsp. *cunninghamiana* to woodland and rocky shrubland. In light of these recently discovered reserved populations a ROTAP coding of 3RCa is considered more appropriate.

7. *Chiloglottis platyptera* D.L. Jones (family Orchidaceae)

Poorly known, scattered north from the Barrington Tops, reserved in Barrington Tops NP. A population of at least 50 plants has recently been recorded growing on

metasediment near Steepdrop Falls in Oxley Wild Rivers NP. A similar sized population has also been discovered in Butterleaf State Forest. Assigned a code of 2KC- (Briggs & Leigh 1996), in light of these northerly range extensions a code of 3KC- is more appropriate.

8. *Chiloglottis sphyrnoides* D.L. Jones (family Orchidaceae)

The exact distribution of this rare species is uncertain, as it has been previously confused with a closely related, unnamed species (Bishop 1996). Recent surveys by the NSW National Parks and Wildlife Service have found significant populations in Chaelundi, Guy Fawkes River and Barool NPs and Glen Nevis, Mt Mitchell and Forestland State Forests (P. Richards pers. comm. 1998). A large population of several hundred plants was also found widely spread throughout tall open forest on metasediment in Werrikimbe NP (Copeland 1999). Assigned a code of 3KC- (Briggs & Leigh 1996), these recent findings suggest a code of 3RCa would be more appropriate.

9. *Cynanchum elegans* (Benth.) Domin (family Asclepiadaceae)

This rainforest climber appears to consist of small isolated populations, often with less than 30 plants. The ROTAP status of 3ECi (Briggs & Leigh 1996) was mainly based on a limited number of sites in Woko NP and Camels Hump NR.

Populations have since been recorded in Wollemi NP, New England NP, Coorumbene Wildlife Refuge, Booti Booti State Recreation Area, Sea Acres NR and Hallidays Point Rainforest Reserve. Two additional populations have also been discovered growing on the margins of closed-forest patches in Oxley Wild Rivers NP. Few plants were observed but it is likely that a more thorough search of the area (including other closed-forest patches) may reveal more individuals. Other unreserved populations are known to occur as far south as Wollongong and north to south-eastern Queensland (A. Bofeldt pers. comm. 1998). On the basis of the large number of newly recorded populations a ROTAP code of 3VCi is considered more appropriate. This species is still considered vulnerable due to the small size of its very scattered populations.

10. *Derwentia arenaria* (Benth.) B.G. Briggs & Ehrend. (family Scrophulariaceae)

Rare species coded 3RC- (Briggs & Leigh 1996) with a widespread but disjunct distribution in northern NSW and southern Queensland. It is an annual and this may account for the paucity of records. Reserved in Warrumbungle and Warrabah NPs and the Torrington State Recreation Area (Clarke et al. 1998).

Extensive populations have recently been found in Ironbark NR and the neighbouring property 'Bornhardtia'. Population numbers within the reserves described above are thought to exceed 1000 individuals and therefore a code of 3RCa is considered appropriate.

11. *Dodonaea rhombifolia* Wakef. (family Sapindaceae)

Widely dispersed from East Gippsland in Victoria to south-eastern NSW with disjunct occurrences in northern New South Wales. The species is reserved in at least 12 Conservation Reserves. Recently collections were made within Washpool NP western additions on the face of a metasediment rock outcrop and representing a northern extension of range. The current 3RCa coding is considered appropriate.

12. *Euphrasia ciliolata* W.R. Barker (family Scrophulariaceae)

Poorly known species with a scattered distribution from Barrington Tops to Backwater on the Northern Tablelands. Two populations of at least 100 plants each have been observed on the margins of swamps in Werrikimbe NP, one near the Hastings River, growing on granitic soils and one near Racecourse Swamp, restricted to a metasediment substrate. These populations are intermediate in distribution between the populations in the Barrington Tops area and the recently recorded population in Cathedral Rock NP (S. Horton pers. comm. 1998). In light of these northerly populations the ROTAP code of 2KC- (Briggs & Leigh 1996) would be more appropriate as 3KC-.

13. *Eucalyptus dorrigoensis* (Blakely) L.A.S. Johnson & K.D. Hill (family Myrtaceae)

Occurs from north-east of Tenterfield along the escarpment to the Macleay River, reserved within Boonoo Boonoo, Dorrigo and Guy Fawkes River NPs, Dorrigo White Gum Flora Reserve and Demon NR.

Extensive populations were found in most areas in Washpool NP western additions (Hunter 1998) and, along with recent surveys carried out by NSW State Forests, support a ROTAP code of 3RCa.

14. *Eucalyptus subcaerulea* K.D. Hill (family Myrtaceae)

This recently described species was thought to be restricted to a few small stands within Gibraltar Range State Forest and around Cooraldooral Trig. Although these localities were not within the reserve network Hill (1997) assigned a ROTAP code of 2RC. Following recent changes to the reserve system these areas are now included in Barool NP.

A large and extensive population of this species has been found recently in the Washpool NP western additions and represents a northern extension of range and the largest extant population of this taxon. Although geographically restricted this is a resilient species that occurs in areas not subject to threatening processes. A code of 2RCat is considered appropriate.

15. *Leionema ambiens* (F. Muell.) Paul G. Wilson (family Rutaceae)

Locally abundant in some granite outcrop communities (Hunter & Clarke 1998) but restricted to north-eastern New South Wales and south-eastern Queensland. NSW populations are known from Bald Rock, Warra and Boonoo Boonoo NPs and Torrington State Recreation Area. Three plants have recently been found along Dandahra Creek in Gibraltar Range NP.

In recent times the large population in Warra NP has been heavily grazed by feral goats, resulting in the death of many plants (P. Richards pers. comm. 1998). The species is susceptible to soil compaction by goats in what is a very specialised habitat and also appears to be killed by fire. On the basis of these threats it is recommended that the ROTAP code be upgraded from 3RC- to 3VC- reflecting the taxon's vulnerability to current threatening processes.

16. *Leucopogon cicatricatus* J. Powell (family Epacridaceae)

This species has been recorded from a number of widely disjunct populations in north-eastern NSW and south-eastern Queensland. Reserved populations are currently known from Girraween and Mount Barney NPs in Queensland and Butterleaf, New England, Cathedral Rock, Tapin Tops and Werrikimbe NPs in NSW. Richards and Hunter (1997) have suggested a ROTAP code of 3RCa (previously 3RC-: Briggs & Leigh 1996).

A population of four plants was recently found at Sundew Lookout, south-east of Glen Innes. Plants were growing in crevices of a granite outcrop largely covered by heath dominated by *Kunzea bracteolata*. Searches of similar outcrops in the adjacent Guy Fawkes River NP may reveal further individuals in what seems to be a very small, disjunct population.

17. *Ozothamnus adnatus* DC. (family Asteraceae)

A widespread species known from a number of populations from the Guyra district to Victoria where it is reserved in Snowy River NP. In north-eastern NSW it is known from Oxley Wild Rivers, Guy Fawkes River and Cathedral Rock NPs.

Two new populations have been discovered on the Northern Tablelands. Eight plants were observed growing in dry sclerophyll forest dominated by *Eucalyptus melliodora*, *E. blakelyi* and *E. viminalis* in Imbota NR, eight kilometres south-east of Armidale. A search of the wider area did not locate any additional plants, suggesting that this very small population may be in danger of extinction. A larger population was recently recorded growing on metasediment around the rim of Rowleys Creek Gorge in Oxley Wild Rivers NP (Copeland 1997). At least 20 mature plants and a number of seedlings were seen over a distance of approximately 500 m of gorge rim.

Briggs and Leigh (1996) assigned the ROTAP code of 3KC-, however in light of the populations known from these four northern reserves and other unreserved populations (J. Williams, pers. comm. 1998) a code of 3RC- is more appropriate.

18. *Thelionema grande* (C. White) R. Henderson (family Phormiaceae)

Recorded sporadically from north of Howell to south-eastern Queensland. Coded 3RC- (Briggs & Leigh 1996) and known from Girraween, Warra, Mount Barney, Boonoo Boonoo and Gibraltar Range NPs and Torrington State Recreation Area (Clarke et al. 1998).

Populations have recently been discovered in Ironbark NR and the adjoining 'Bornhardtia' private property and it is believed that infertile material found in Werrikimbe NP also belongs to this species. These records represent a southern extension of range. All populations found in these areas were restricted to isolated granitic outcrops near watercourses. Due to the size of populations within known reserves a code of 3RCa is considered more appropriate.

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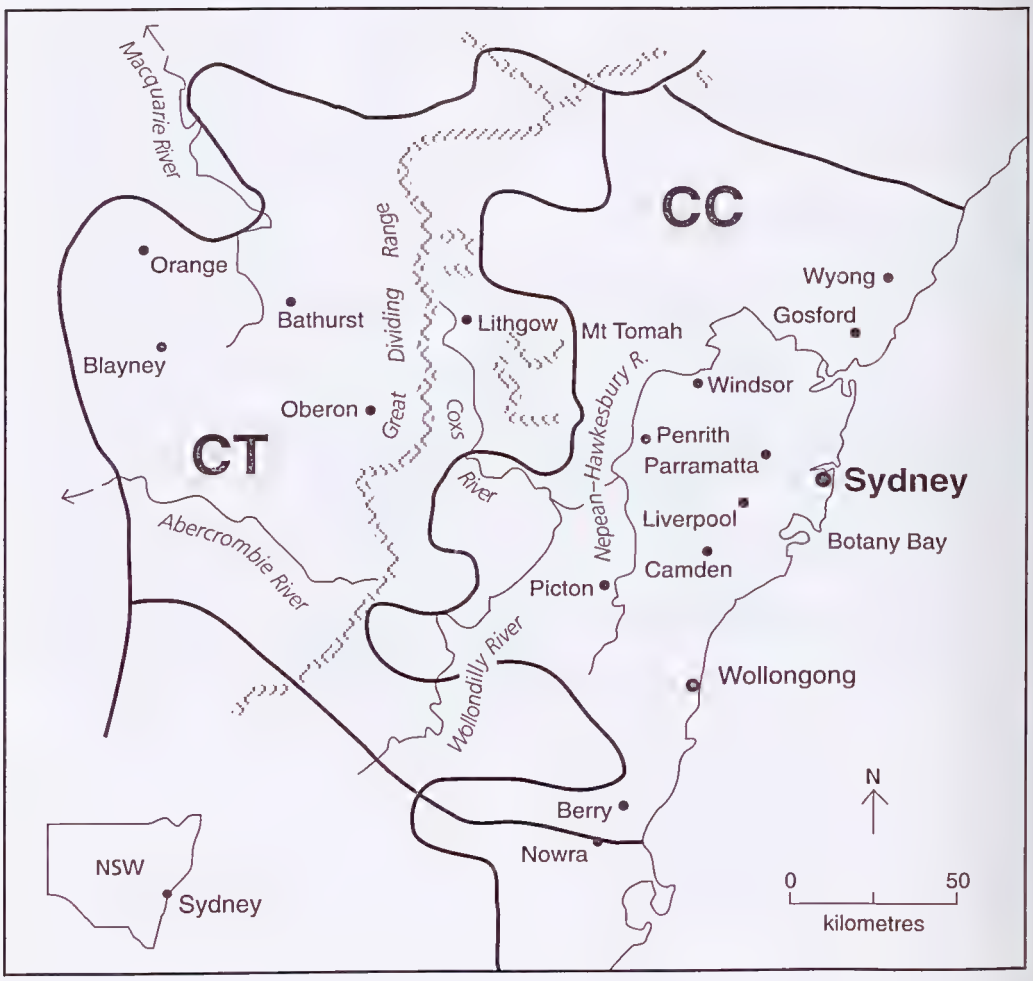

Map of the Sydney region

For the Ecology of Sydney Plant Species the Sydney region is defined as the Central Coast and Central Tablelands botanical subdivisions.

Ecology of Sydney plant species

Part 7a Dicotyledon families Nyctaginaceae to Primulaceae

Doug Benson and Lyn McDougall

Abstract

Benson, Doug and McDougall, Lyn (National Herbarium of New South Wales, Royal Botanic Gardens, Sydney, Australia 2000. Email: Doug_Benson@rbgsyd.gov.au) 1999 Ecology of Sydney plant species: Part 7a Dicotyledon families Nyctaginaceae to Primulaceae. Cunninghamia *6(2) 402 to 509.* Ecological data in tabular form are provided on 149 plant species of the families Nyctaginaceae to Primulaceae, 75 native and 74 exotics, occurring in the Sydney region, defined by the Central Coast and Central Tablelands botanical subdivisions of New South Wales (approximately bounded by Lake Macquarie, Orange, Crookwell and Nowra). Relevant Local Government Areas are Auburn, Ashfield, Bankstown, Bathurst, Baulkham Hills, Blacktown, Blayney, Blue Mountains, Botany, Burwood, Cabonne, Camden, Campbelltown, Canterbury, Cessnock, Concord, Crookwell, Drummoyne, Evans, Fairfield, Greater Lithgow, Gosford, Hawkesbury, Holroyd, Hornsby, Hunters Hill, Hurstville, Kiama, Kogarah, Ku-Ring-Gai, Lake Macquarie, Lane Cove, Leichhardt, Liverpool, Manly, Marrickville, Mosman, Mulwaree, North Sydney, Oberon, Orange, Parramatta, Penrith, Pittwater, Randwick, Rockdale, Ryde, Rylstone, Shellharbour, Shoalhaven, Singleton, South Sydney, Strathfield, Sutherland, Sydney City, Warringah, Waverley, Willoughby, Wingecarribee, Wollondilly, Wollongong, Woollahra and Wyong.

Families are: Nyctaginaceae, Nymphaeaceae, Ochnaceae, Olacaceae, Oleaceae, Onagraceae, Oxalidaceae, Papaveraceae, Passifloraceae, Peperomiaceae, Piperaceae, Pittosporaceae, Plantaginaceae, Plumbaginaceae, Polemoniaceae, Polygalaceae, Polygonaceae, Portulacaceae, Primulaceae.

Data are derived from herbarium collections, literature and field observations. It is hoped that the many, often alarming gaps in the information available will stimulate much-needed research into the ecology of more of the species. Information is provided so far as available to us for each plant species in the following categories:

Life History: Growth form, vegetative spread, longevity, primary juvenile period (time from germination to fruiting), reproduction, flowering and fruiting times, fruit/seed type, dispersal, establishment and growth, fire response, interaction with other organisms.

Distribution: Status/origin (native/naturalised), botanical subregions, distribution in Sydney area, selected locations.

Habitat: Habitat, altitude, annual rainfall, typical local abundance, vegetation, substrate, exposure.

Conservation: Conservation status.

Introduction

The *Ecology of Sydney plant species* aims to provide ecological information on native and naturalised Sydney plants. Particular emphasis has been given to data that are relevant for ecologists and natural area managers, for people involved in bush regeneration, land rehabilitation and landscape design, for researchers in many fields and for a wide range of people who are interested in bushland and native plants. Species-specific information is also relevant to environmental impact assessment and to studies involving changes in drainage, water movement, wind exposure, nutrient conditions and fire regimes on plant species and plant communities. Information included covers growth form, flowering and fruiting times, longevity and maturation periods, pollination and seed dispersal data, distribution, habitat and plant community, as well as responses to fire and disturbance where available and is complementary to the descriptive texts in taxonomic handbooks such as the *Flora of New South Wales* (Harden 1990–93).

Part 7 covers families from Nyctaginaceae to Rubiaceae, approximately 400 species, including Proteaceae, many species of which have a considerable amount of information. Because of the size of this Part, and the extent of research involved compared with other parts, it has been necessary to divide the work into two sections.

Part 7a of the *Ecology of Sydney plant species* covers the Dicotyledon families alphabetically from Nyctaginaceae to Primulaceae.

Part 7b, Proteaceae to Rubiaceae will be published in 2000.

Methods

Part 7a follows the format used in Parts 1–6 (Benson & McDougall 1993, 1994, 1995, 1996, 1997, 1998). The Sydney region is defined as the Central Coast and Central Tablelands botanical subdivisions (i.e. approximately bounded by Lake Macquarie, Orange, Crookwell and Nowra) (Fig. 1). This is the area broadly covered by *Flora of the Sydney Region* (Carolin & Tindale 1993), with the exception that the Hunter Valley is not included here since it lies within the North Coast and Central Western Slopes subdivisions. Relevant Local Government Areas are Auburn, Ashfield, Bankstown, Bathurst, Baulkham Hills, Blacktown, Blayney, Blue Mountains, Botany, Burwood, Cabonne, Camden, Campbelltown, Canterbury, Cessnock, Concord, Crookwell, Drummoyne, Evans, Fairfield, Greater Lithgow, Gosford, Hawkesbury, Holroyd, Hornsby, Hunters Hill, Hurstville, Kiama, Kogarah, Ku-Ring-Gai, Lake Macquarie, Lane Cove, Leichhardt, Liverpool, Manly, Marrickville, Mosman, Mulwaree, North Sydney, Oberon, Orange, Parramatta, Penrith, Pittwater, Randwick, Rockdale, Ryde, Rylstone, Shellharbour, Shoalhaven, Singleton, South Sydney, Strathfield, Sutherland, Sydney City, Warringah, Waverley, Willoughby, Wingecarribee, Wollondilly, Wollongong, Woollahra and Wyong.

The Sydney region, as defined here, includes approximately 3500 plant species, both native and naturalised. To deal effectively with this number, the work has been divided into parts each of approximately 350 species based on plant families beginning with ferns, Cycads and Gymnosperms, and then Dicotyledon and Monocotyledon families. Within these groups, families, genera and species are arranged alphabetically.

Part 1: Ferns, Fern allies, Cycads and Conifers, Dicotyledon families Acanthaceae to Asclepiadaceae (*Cunninghamia* 3(2) 1993)

Part 2: Dicotyledon families Asteraceae to Buddlejaceae (*Cunninghamia* 3(4) 1994)

Part 3: Cabombaceae to Eupomatiaceae (*Cunninghamia* 4(2) 1995)

Part 4: Fabaceae (*Cunninghamia* 4(4) 1996)

Part 5: Flacourtiaceae to Myrsinaceae (*Cunninghamia* 5(2) 1997)

Part 6: Myrtaceae (*Cunninghamia* 5(4) 1998)

Part 7a: Nyctaginaceae to Primulaceae (*Cunninghamia* 5(6) 1999)

Part 7b: Proteaceae to Rubiaceae

Part 8: Rutaceae to Zygophyllaceae

Part 9: Monocotyledon families

Part 10: Monocotyledon families

For each species (and generally for subspecies) a data sheet is prepared incorporating life history, distribution and habitat data from specimens in the National Herbarium of New South Wales; this information is entered in a database together with data from literature sources both published and unpublished. References have been cited where appropriate but for unreferenced data responsibility has been assumed by the authors. A provisional compilation sheet with the available information is then prepared and distributed to interested persons for comments and additions/alterations. This compilation is then published in parts in the summer issue of *Cunninghamia,* with the subsequent long-term aim of producing a book at the completion of the ten parts. This will allow the incorporation of new and additional material.

Part 7b, Proteaceae to Rubiaceae, is planned for publication in 2000, and any information that readers would like included should be sent to the authors by 30 June 2000.

Ecological review papers may be appropriate for families in future issues, particularly the major families e.g. Proteaceae, but papers would also be welcomed for smaller families. Authors interested in contributing such papers should contact the Scientific Editor.

Information categories

For each species or subspecies, information is presented under headings relating to different life-history aspects, each with further subdivisions. Emphasis has been given to understanding the species in its wild habitat. For this reason data on cultivation and artificial propagation, available in horticultural books, are generally not included. Likewise information on weed control is not given. Generally, the categories are broadly interpreted and since the project aims to stimulate further investigation, we welcome the addition of extra data on any other aspects of the plant's ecology.

A 'comments' section has been deliberately avoided — for all information retrieval purposes, all ecological material should be attributable to some life history aspect of the plant or its habitat although even with our broad categories there have been problems with 'Vegetation' and 'Substrate' sections for specialised lifeforms such as mistletoes. The main purpose of this information is to give a picture of the ecology of particular species as is currently known. It is not primarily for comparative purposes although it can be used in this way. One of our original aims was to demonstrate that closely related species may have different ecologies and that to generalise within genera for example rather than look at a particular species is an over simplification. We have also included reference to individualistic information resulting from specific research that will not necessarily be available for all species.

Similarly where we have observations on the effects of factors such as drought on particular species we have included these, though we have not included a category for 'drought' because of difficulties in definition. One of our aims is to be open-ended, to point out that there are many gaps in the ecological knowledge and to indicate areas and species where future work may be particularly useful.

Botanical nomenclature

Family/Genus/Species: Names currently recognised at the National Herbarium of NSW and mostly as used in *Flora of New South Wales.*

Common name: Names used in *Flora of New South Wales.*

Life history

Growth form: Brief description.

Source: *Flora of New South Wales.*

Vegetative spread: Indication of whether localised expansion or spread is possible from an individual by rhizome, stolon, rootsucker etc. Important in determining ability of species to colonise immediate local area. Does not include vegetative distance-dispersal which is included under Establishment & Growth (diaspore).

Source: Flora descriptions, Herbarium specimens, field observations.

Longevity: Average potential life-span under natural conditions — range in years where possible, indefinite, where death is not a result of inherent growth e.g. continued rhizomatous growth. Longevity may be shorter in cultivation. There are very few references in the literature to the longevity of species or records of individual plants, particularly of the longer-lived species, yet this is an important factor in assessing importance of recruitment and changes in plant communities.

Most of the estimates given are based on the authors' judgement, based on the shape, size and growth rates of individuals, and the authors' experience in the field over 25 years, together with any historical data available. The figures given are conservative and represent minimal average ages. The authors would not be surprised if much greater ages are achieved in many cases.

Source: literature, authors' assessment from field observations.

Primary juvenile period: time taken from germination to produce first fruits or spores. Gill (1975) uses the term for the period from germination to flowering but the period to fruit maturity is more significant ecologically. Secondary juvenile period is time taken for individual to recover to produce fruit after major damage e.g. from fire, but applicable only if species regularly resprouts. The time required to accumulate a seedbank sufficient to ensure reasonable recruitment in the event of mass mortality is also an important consideration. Primary and secondary juvenile periods should not be considered as absolute and they may vary spatially as a function of habitat factors (moisture availability, nutrients etc.) and temporally (e.g. climatic variation).

Source: literature, field observations.

Reproduction: for Angiosperms, reproduction is separated into:

Flowers: predominant flower colour, flowering period — range of months and, where possible, peak month based on frequency of herbarium collections. Pollination vectors.

Fruit: fruit shape and size, particularly with respect to potential dispersal agents. Maturation period. Seed size and number.

Source: Herbarium specimens, field observations, *Flora of New South Wales*, literature.

Establishment and growth: diaspore type (including vegetative), dispersal agent. Germination requirements: seedbank presence, dormancy, growth rates, seasonality, deciduousness etc. [notes on propagation in cultivation may be given where these imply similar behaviour under natural field conditions e.g. insights into seed germination inhibition].

Source: literature, field observations.

Fire response: general response of mature plant to fire, in particular whether it generally resprouts or is killed (see also Gill 1981, Gill & Bradstock 1992). Seedling recruitment associated with fire is included under establishment and growth. Entries such as 'probably killed' mean that a species has no obvious morphological characteristics likely to assist in surviving and resprouting following fire. While species that resprout after fire may be readily noted, the death of individuals may not be observed unless the occurrence of the species in the area was well known prior to the fire.

For a given species some populations may be capable of resprouting while other populations may be killed. This may explain cases where contradictory evidence has been given though response to fire in some species may depend on fire intensity.

In view of the limited information available for many species, the categories of Gill and Bradstock have not been applied at this stage.

Source: field observations, literature.

Interaction with other organisms: symbiosis, predators, diseases etc.

Source: mainly literature.

Distribution

Status/origin: native or naturalised, region of origin, source and date of introduction/ naturalisation. Naturalised species indicated by an asterisk following the botanical name.

Source: *Flora of New South Wales*, literature.

Botanical subregions: occurrence of species in botanical subdivisions of NSW, other states and countries.

Source: National Herbarium of New South Wales.

Distribution in Sydney region: main geographic regions occupied by species.

Source: Herbarium specimen records.

Selected locations: restricted to about 10 localities for each taxon reflecting natural geographical range of species in the Sydney area. Earliest collection dates are given for some species, particularly exotic species. Recent collection sites indicated where possible. Locality data must be interpreted carefully. The record may be based on an old specimen or observation record and the species may no longer be present at the site. However a knowledge of the original distribution may be important in showing up particular habitat requirements of the species.

Source: Herbarium specimen records.

Habitat

Specific data refer to Sydney area unless stated otherwise.

Habitat: brief generalised description.

Source: Herbarium specimen records, field observations.

Altitude: approximate altitudinal range (m +/- 100 m) occupied by the species,

Source: Herbarium specimen records.

Annual rainfall: approximate annual rainfall range (mm +/- 100 mm) for sites occupied by the species.

Source: Bureau of Meteorology (1979).

Typical local abundance: most frequent recordings (scale: dominant/frequent/ occasional/rare)

Source: Herbarium specimen records.

Vegetation: main structural type with typical associated species where available.

Source: Herbarium specimen records, field observations, literature.

Substrate: geology, soil, moisture supply.

Soil nutrient rating scale: very fertile (high nutrient) (e.g. basalt soils)/ fertile (moderate nutrient)/ infertile (low nutrient)/ very infertile (very low nutrient) (e.g. sands).

Soil salinity scale: hypersaline/ saline/ brackish/ fresh.

Source: Herbarium specimen records, field observations, literature.

Exposure:

Exposure scale: exposed/ indifferent/ sheltered.

Shading scale: deep shade/ mid shade/ light shade/ no shade.

Source: Herbarium specimen records, field observations, literature.

Conservation

Conservation: national significance listing (Briggs & Leigh 1996), with current updating for Rare or Threatened Australian Plants (ROTAP) database maintained by NSW NPWS; inclusion on schedules of the NSW *Threatened Species Conservation Act 1995*; comments on regional significance and adequacy of conservation within Sydney area are based on authors' knowledge of the abundance of species and their primary occurrence in major conservation areas. These comments apply to the Sydney region; a species may be common or rare elsewhere. 'Probably' is used in many cases as it is the authors' views that a definite categorisation of 'adequately conserved' needs to be based on a better knowledge of the species' biology and distribution than we have at present for most species.

Source: Herbarium records, field observations, literature.

General comments on part 7a

Part 7a covers 149 plant species of the families Nyctaginaceae to Primulaceae, 75 native and 74 naturalised exotics.

Excluded from this work are a number of exotic species that do not appear to be truly naturalised in the Sydney region (*Fagopyrum esculentum, Ligustrum vulgare, Plantago scabra, Rumex hymenosepalus, Rumex stenoglottis*).

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Dicotyledon families Nyctaginaceae to Primulaceae

Boerhavia coccinea NYCTAGINACEAE

Tarvine

Life history

Growth form: Prostrate to decumbent perennial herb, with hairy stems.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Pink.
Fruit/seed: 1-seeded indehiscent fruit with glandular hairs, mucilaginous when wet, 3–5-ribbed, 3–4 mm long.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CC NT CT ?ST NWS CWS SWS NWP SWP NFWP SEWP; Qld, N.T., S.A., W.A.
Distribution Sydney area:
Select locations:

Habitat

Habitat: Riverbanks.
Altitude: 0–800 m **Annual rainfall:** 600–800 mm
Typical local abundance: Frequent–occasional.
Vegetation: Grassy sites.
Substrate: Alluvial soil, gravelly slopes, low to medium nutrients.
Exposure:

Conservation

Conservation: Conservation status unknown.

Mirabilis jalapa * NYCTAGINACEAE

Four-o'clock, Marvel of Peru

Life history

Growth form: Erect perennial herb to 1 m high, with woody rootstock and large tuberous roots; leaves opposite.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: White, yellow or red, or a mixture of these colours; flowers open in the afternoon, March–April.
Fruit/seed: Dry, 1-seeded fruit, indehiscent, 7 mm long.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to America; introduced as ornamental.
Botanical subregions: NC CC; LHI, Qld, Vic.
Distribution Sydney area:
Select locations: **CC:** Woolloomooloo, Valley Heights (1954).

Habitat

Habitat: Waste sites, embankments.
Altitude: 0–400 m **Annual rainfall:** 1100–1400 mm
Typical local abundance: Frequent.
Vegetation: Weedy sites e.g. with *Lantana camara.*
Substrate:
Exposure:

Conservation

Conservation: Occasional escape from cultivation, not common, unlikely to invade bushland.

Pisonia umbellifera NYCTAGINACEAE

Birdlime Tree

Life history

Growth form: Small, brittle tree 4–6 m high, with very sticky fruit.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Pale green, without petals; male flowers bell-shaped, April.
Fruit/seed: Dry, 1-seeded, 5-ribbed fruit 2–4 cm long. Exudes a dark sticky gum, mature February–May (Floyd 1989).
Dispersal, establishment & growth: Diaspore: sticky fruit, dispersed by attachment to Flying Foxes (Fuller & Badans 1980) and birds.
Fire response:
Interaction with other organisms: Sticky fruit sometimes sticks to birds, bats and reptiles causing death (Harden 1990).

Distribution

Status/origin: Native.
Botanical subregions: NC CC SC; Qld, LHI, Malesia, Pac Is, Afr.
Distribution Sydney area: Illawarra.
Select locations: **CC:** Burning Palms RNP, Clifton, Austinmer, Minnamurra Falls, Saddleback Mountain.

Habitat

Habitat: Gullies, rear of upper bench of escarpment (Fuller & Badans 1980).
Altitude: 0–200 m **Annual rainfall:** 1400–1600 mm
Typical local abundance: Occasional–common.
Vegetation: Subtropical rainforest e.g. with *Streblus brunonianus, Dendrocnide excelsa, Dospyros australis, Cassinia australis.*
Substrate: Clay soil on volcanics, high nutrients.
Exposure:

Conservation

Conservation: Not common, conservation status unknown.

Nymphaea caerulea subsp. *zanzibarensis* * NYMPHAEACEAE

Cape Waterlily

Life history

Growth form: Perennial aquatic herb with floating leaves and small tubers that may develop into short vertical rhizomes; leaf circular with a radial slit.
Vegetative spread: No.
Longevity:
Primary juvenile period:
Flowers: Blue or rarely white; flowers remain open for 4–5 days, closing at night, late spring to early winter (Sainty & Jacobs 1981).
Fruit/seed: Berry, drawn below water surface by the spiralling stalk, with numerous seeds 2 mm long.
Dispersal, establishment & growth: Seeds germinate from spring to autumn on mud in water up to 1 m deep (Sainty & Jacobs 1981).
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to S Africa.
Botanical subregions: NC CC; Qld, S Afr.
Distribution Sydney area:
Select locations: CC: Cooranbong (1960), Moonee Moonee Creek, Gees Lagoon, Wheeny Creek, Marley Lagoon.

Habitat

Habitat: Creeks, lagoons.
Altitude: 0–200 m **Annual rainfall:** 900–1600 mm
Typical local abundance: Frequent.
Vegetation: Semi-permanent fresh swamp e.g. with *Eleocharis sphacelata, Triglochin procera.*
Substrate: Grows in shallow water usually to 1 m deep, but can tolerate up to 2 m; can grow in soft mud or heavier clays or in poorer soils with nutrient input e.g. dams (Sainty & Jacobs 1981).
Exposure: Full sun.

Conservation

Conservation: Naturalised in a wide range of perennial water bodies on the coast.

Nymphaea mexicana * and hybrids NYMPHAEACEAE

Life history

Growth form: Perennial aquatic herb with floating leaves and vertical rhizomes to 30 cm long, 4 cm thick. Stolons produced at the top of the rhizome.
Vegetative spread: Stolons or small plants produced at the end of stolons may break off and establish elsewhere (Sainty & Jacobs 1981).
Longevity:
Primary juvenile period:
Flowers: Yellow, November–February.
Fruit/seed: Berry with large dark brown seeds though rarely form in NSW (Sainty & Jacobs 1981).
Dispersal, establishment & growth:
Fire response: Unlikely to be burnt.
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to America.
Botanical subregions: CC; Qld, Amer.
Distribution Sydney area: Suburban ponds.
Select locations: CC: Eastlakes, Lane Cove, Lake Parramatta, Centennial Park.

Habitat

Habitat: Deep lagoons, dams or slow-flowing creeks (Sainty & Jacobs 1981).
Altitude: 0–20 m **Annual rainfall:** 1000–1200 mm
Typical local abundance: Frequent.
Vegetation:
Substrate: Can grow in water 2 m deep or more, encouraged by high nutrient input (Sainty & Jacobs 1981).
Exposure: Full sun.

Conservation

Conservation: Mainly cultivated but naturalised and spreading in some coastal areas. Care needed to prevent establishment in water bodies with high nutrient input (Sainty & Jacobs 1981).

Ochna serrulata * OCHNACEAE

Life history

Growth form: Shrub 2–3 m high, with conspicuous lenticels on stems and branches; leaves with toothed margins.
Vegetative spread: No.
Longevity:
Primary juvenile period:
Flowers: Yellow, August.
Fruit/seed: Cluster of black fleshy fruits 5–8 mm long, embedded on the swollen red top of flower stalk, November.
Dispersal, establishment & growth: Diaspore: fruit, dispersed by birds and animals. Vertebrate-adapted dispersal (Westoby et al. 1990). Fruit reported from pellets of Currawongs (Buchanan 1989a).
Fire response: Resprouted after high intensity fire (1/94) at Lane Cove and Narrabeen; secondary juvenile period less than 2 years (P. Kubiak pers. comm.).
Interaction with other organisms: Flowers visited by native bee and small weevils (Curculionidae) (P. Kubiak pers. comm.).

Distribution

Status/origin: Exotic, native to S Africa. Introduced as ornamental.
Botanical subregions: CC NC.
Distribution Sydney area: Widespread in suburban areas.
Select locations: **CC:** Gosford, Eastwood, Northbridge, Bradleys Head, Campbelltown, Wollongong.

Habitat

Habitat: Urban bushland.
Altitude: 0–200 m **Annual rainfall:** 700–1400 mm
Typical local abundance: Frequent–occasional.
Vegetation: Woodland e.g. with *Eucalyptus piperita.*
Substrate: Sandy soil on sandstone, low nutrients, well-drained.
Exposure: Mid to light shade.

Conservation

Conservation: Garden escape, frequently naturalised in urban bushland. Difficult to remove as it can resprout from a deep taproot; even removal of small plants is tricky because the taproot usually has a twisted section and easily breaks off.

Olax stricta OLACACEA

Life histor

Growth form: Erect shrub to 2 m high with yellowish-green leaves; hemiparasitic on the roots of other plants e.g. adheres to roots of any host plant within range by a large, soft, whitish cushion that may almost envelope the smaller roots of the host plant, absorbing organic and inorganic materials (McLuckie & McKee 1954).
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: White to yellowish, flowers throughout the year but with peak in September. Probably pollinated by honeybees and native bees, with wasps playing a minor role (P. Kubiak pers. comm.).
Fruit/seed: Fleshy, 4–8 mm long
Dispersal, establishment & growth:
Fire response: Stems killed, resprouts at base or below (Fox 1988); secondary juvenile period 3.5 years at Lane Cove (P. Kubiak pers. comm.).
Interaction with other organisms: Possibly eaten by rabbits (P. Kubiak pers. comm.).

Distributio

Status/origin: Native.
Botanical subregions: NC CC SC NT CT ST NWS CWS; Qld, Vic.
Distribution Sydney area: Widespread.
Select locations: **CC:** Kulnura, Woy Woy, Glenorie, Berkshire Park, Hornsby, Wahroonga, Waterfall, Manly, Bulli Pass, Springwood. **CT:** Rylstone, Yetholme, Mt Victoria, Hill Top, Robertson, Bundanoon.

Habita

Habitat: Rocky ridges and hillsides.
Altitude: 0–1000 m **Annual rainfall:** 900–1400 mm
Typical local abundance: Frequent–occasional.
Vegetation: Woodland e.g. with *Eucalyptus haemastoma, Corymbia gummifera, Angophora hispida*; heath e.g. with *Banksia ericifolia, B. oblongifolia, Acacia suaveolens, Grevillea buxifolia, Lambertia formosa.*
Substrate: Shallow sandy soil on sandstone, often with ironstone gravel or sandy soil over clay subsoil, low nutrients.
Exposure: Full sun.

Conservation

Conservation: Occurs in major national parks e.g. Brisbane Water NP, Blue Mountains NP, Ku-ring-gai NP, Royal NP.

Ligustrum lucidum * OLEACEAE

Large-leaved Privet

Life history

Growth form: Shrub or small tree to 10 m high, with conspicuous lenticels on the stem; leaves opposite.
Vegetative spread: No.
Longevity: 50–100 years.
Primary juvenile period:
Flowers: White flowers strongly scented, January–February. Probably pollinated by honeybees mainly, also flies and beetles, with moths and butterflies playing a minor role (P. Kubiak pers. comm.).
Fruit/seed: Blue-black globose berry 8 mm long, May–August.
Dispersal, establishment & growth: Diaspore: fruit, vertebrate-adapted for dispersal (Westoby et al. 1990). Fruit reported from pellets of Currawongs (Buchanan 1989a). Seed germinates well at 15°C, poor germination above 20°C and below 10°C in shady conditions (M. Clarke pers. comm.).
Fire response: Resprouted after high intensity fire (1/94) at Lane Cove, flowering in 3 years (P. Kubiak pers. comm.).
Interaction with other organisms: Can cause allergic reactions in humans (Bass 1990). Fruit eaten by Grey-headed Flying Fox *Pteropus poliocephalus* (Eby 1995). Fruit and leaves may be poisonous to small children and stock (Harden 1992).

Distribution

Status/origin: Exotic, native to China and Japan.
Botanical subregions: NC CC SC ST NWS CWS SWS; Qld.
Distribution Sydney area: Widespread.
Select locations: **CC:** Beecroft, Naremburn, Oatley, Casula, Douglas Park, Cobbity, Picton, Minnamurra Falls, Berry. **CT:** Robertson

Habitat

Habitat: Moist nutrient-rich sites on creekbanks, gullies, downslope of stormwater drains.
Altitude: 0–600 m **Annual rainfall:** 700–1600 mm
Typical local abundance: Occasional–frequent.
Vegetation: Rainforest e.g. with *Doryphora sassafras*; open-forest e.g. riverine forest.
Substrate: Clay soils on basalt, alluvium, high nutrients.
Exposure: Light shade.

Conservation

Conservation: Agressive bushland weed forming dense stands, out-competing native vegetation e.g. on creekbanks; can occur in relatively undisturbed bushland.

Ligustrum sinense * OLEACEAE

Small-leaved Privet

Life history

Growth form: Shrub to 3 m high, with conspicuous lenticels on the stems. New growth pubescent; leaves opposite.
Vegetative spread: Very limited; can sucker from roots if main stems destroyed. Buried root segments can re-establish (Mowatt & Smith 1983).
Longevity: 50–100 years.
Primary juvenile period:
Flowers: White flowers strongly scented, September–January. Honeybees are probably the main pollinators, beetles and flies probably also significant, with butterflies and moths playing a minor role; *Ligustrum sinense* probably attracts a greater diversity of native insects than other weeds in Sydney bushland (P. Kubiak pers. comm.).
Fruit/seed: Black berry 5 mm long, May–September.
Dispersal, establishment & growth: Diaspore: fruit, vertebrate-adapted for dispersal (Westoby et al. 1990). Fruit reported from pellets of Currawongs (Buchanan 1989a). Almost all seed is viable but will not germinate until removed from the fruit; seed viability for at least 2 years if stored at low temperatures; seed killed during composting when temperatures c. 60° for several weeks (Mowatt & Smith 1983). Seed germinates well 15–25°C, in shady conditions (M. Clarke pers. comm.). Seedlings establish in low light conditions under adult plants forming dense thickets.
Fire response: Resprouted after high intensity fire (1/94) at Lane Cove and Narrabeen; secondary juvenile period 2.5 years (P. Kubiak pers. comm.).
Interaction with other organisms: Can cause allergic reactions in humans (Bass 1990). Fruit eaten by Grey-headed Flying Fox *Pteropus poliocephalus* (Eby 1995). Seedlings apparently eaten by rabbits; fruit eaten by Crimson Rosellas *Platycercus elegans*, King Parrots *Alisterus scapularis*, Red Whiskered Bulbul *Pycnonotus jocosus*, and Silvereyes *Zosterops lateralis* (P. Kubiak pers. comm.).

Distribution

Status/origin: Exotic, native to China. Introduced as ornamental and widely grown for hedges.
Botanical subregions: NC CC SC CT ST NWS; LHI, Qld.
Distribution Sydney area: Widespread.
Select locations: **CC:** Lisarow, Matcham, Hornsby, Eastwood, Northbridge, Wallacia, Bass Hill, Glenfield, Douglas Park, Campbelltown, Kangaroo Valley. **CT:** Lithgow, Blackheath, Robertson.

Habitat

Habitat: Creeks, gullies.
Altitude: 0–1000 m **Annual rainfall:** 800–1600 mm
Typical local abundance: Frequent.
Vegetation: Open-forest e.g. with *Angophora floribunda, Eucalyptus saligna, E. pilularis, E. piperita.*
Substrate: Clay soils on shale, volcanic rocks, sandy alluvium, high nutrients. Can grow in drier sites than *L. lucidum* (Mowatt & Smith 1983).
Exposure: Mid-shade to full shade.

Conservation

Conservation: A major weed of bushland, commonly naturalised in northern Sydney suburbs by 1950s and spreading since then in moist gullies receiving enriched runoff.

Notelaea longifolia forma *intermedia*

OLEACEAE

Large Mock-olive, Large-leaved Olive

Life history

Growth form: Tree to 9 m high, with hairy leaves, stems and buds; characters intermediate between *Notelaea longifolia and N. microcarpa.*
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Creamish-green, November–March.
Fruit/seed: Bluish black fleshy fruit 10–16 mm long, with one seed.
Dispersal, establishment & growth: Diaspore: fruit, bird-dispersed.
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC CC CWS.
Distribution Sydney area: Coastal.
Select locations: CC: Wattagan SF, Bellbird Hill, Campbelltown, Razorback, Bomaderry Creek.

Habitat

Habitat:
Altitude: 0–400 m **Annual rainfall:** 700–1200 mm
Typical local abundance: Occasional.
Vegetation: Moist eucalypt forest e.g. with *Acacia elata, Eucalyptus saligna;* dry forest e.g. with *Eucalyptus tereticornis, Alphitonia excelsa, Brachychiton populneus.*
Substrate: Clay soil on shale and sandstones, medium nutrients, well-drained.
Exposure:

Conservation

Conservation: Conservation status unknown.

Notelaea longifolia forma *longifolia*

OLEACEAE

Large Mock-olive, Large-leaved Olive

Life history

Growth form: Tree to 9 m high, usually with conspicuous white lenticels; most parts of plant hairy. Two forms recognised in Sydney area forma *longifolia,* forma *intermedia.* The primary root system is replaced by a positively geotropic lignotuber at an early age (Lacey & Jahnke 1984).
Vegetative spread: No.
Longevity:
Primary juvenile period:
Flowers: Creamish green, April–July.
Fruit/seed: Bluish black fleshy fruit 10–16 mm long, with one seed. Mature December. 1065–1095 fruit per kilogram, 3820 seeds per kilogram (Floyd 1989).
Dispersal, establishment & growth: Diaspore: fruit, bird-dispersed, e.g. Currawongs (Wallace 1997). Not viable after storage at room temperature for 1 year; germination occurs after removal of pulp (Floyd 1989). The primary root is short-lived, adventitious roots are produced from the lignotuber at an early stage, and new plants can be grown from segments of the lignotuber (Lacey & Jahnke 1984).

Fire response: Resprouted after high intensity fire (1/94) at Lane Cove; secondary juvenile period less than 2 years (P. Kubiak pers. comm.).
Interaction with other organisms: Fruit eaten by Brown Cuckoo-dove (Floyd 1989). Food plant of butterfly Eastern Flat *Netrocoryne repandra repandra* (Common & Waterhouse 1982).

Distribution

Status/origin: Native.
Botanical subregions: NC CC SC CT ST CWS.
Distribution Sydney area: Widespread.
Select locations: **CC:** Kincumber, Cowan, Beecroft, North Head, Kurnell, Liverpool, Kowmung River, Bomaderry. **CT:** Wingello SF.

Habitat

Habitat:
Altitude: 0–600 m **Annual rainfall:** 700–1400 mm
Typical local abundance: Occasional.
Vegetation: Rainforest e.g. with *Doryphora sassafras, Ceratopetalum apetalum*; eucalypt open-forest e.g. with *Angophora costata, Eucalyptus botryoides, E. paniculata, E. piperita, E. maculata, Angophora floribunda.*
Substrate: Clay soils on volcanic necks, limestone, alluvium, medium nutrients.
Exposure:

Conservation

Conservation: Widespread and probably adequately conserved.

Notelaea neglecta OLEACEAE

Life history

Growth form: Shrub to 2 m high or small tree, branchlets finely hairy to glabrous, axillary buds finely hairy.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Yellow, spring.
Fruit/seed: Fleshy fruit 5–6 mm long.
Dispersal, establishment & growth: Diaspore: fruit
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CT ST.
Distribution Sydney area: Bungonia Gorge to Capertee.
Select locations: **CT:** Capertee, Jenolan Caves, Colong–Yerranderie, Bullio, Wombeyan Caves, Tallong.

Habitat

Habitat: Open-forest.
Altitude: 600–1000 m **Annual rainfall:** 600–1100 mm
Typical local abundance: Occasional.
Vegetation: Eucalypt forest
Substrate: Limestone or occasionally sandstone.
Exposure:

Conservation

Conservation: May be uncommon, last collected 1969. Conservation status not known.

Notelaea ovata OLEACEAE

Life history

Growth form: Shrub to 1 m high.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Pale yellow, May–November.
Fruit/seed: Purplish-black fleshy fruit 8–12 mm long, mature autumn (L. Parkinson pers. comm.).
Dispersal, establishment & growth: Diaspore: fruit.
Fire response: Resprouts.
Interaction with other organisms: Readily grazed by horses.

Distribution

Status/origin: Native.
Botanical subregions: NC CC SC CWS; Qld.
Distribution Sydney area: Mainly coastal.
Select locations: CC: Morisett, Lindfield, Nielson Park, Oatley, Earlwood, Abbotsford, Silverdale, Yerranderie, Austinmer, Bargo River.

Habitat

Habitat: Open-forest.
Altitude: 0–100 m **Annual rainfall:** 900–1400 mm
Typical local abundance: Occasional.
Vegetation: Open-forest e.g. with *Angophora costata, Eucalyptus piperita, E. fibrosa, E. crebra.*
Substrate: Sandy soil over sandstone though often with clay-influence, low–medium nutrients.
Exposure:

Conservation

Conservation: Conservation status unknown.

Notelaea venosa OLEACEAE

Veined Mock-olive, Smooth Mock-olive

Life history

Growth form: Shrub or small tree to 6 m high.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Yellow or greenish-white, spring–summer.
Fruit/seed: Purple to blackish fleshy fruit 15–20 mm long, at any time.
Dispersal, establishment & growth: Diaspore: fruit, vertebrate-adapted for dispersal (Westoby et al . 1990).
Fire response:
Interaction with other organisms: Fruit eaten by Wonga Pigeon (Floyd 1989).

Distribution

Status/origin: Native.
Botanical subregions: NC CC SC CT ST CWS; Qld, Vic.
Distribution Sydney area: Widespread.
Select locations: CC: Mt Warrawolong, Bilpin, Wondabyne, Springwood, Bulli, Wollongong, Bass Point, Albion Park, Cambewarra Range. **CT:** Mt Darcy, Mt Wilson, Wentworth Falls, Kanangra, Hill Top, Robertson, Wingello SF.

Habitat

Habitat: Deep gullies, along creeks.
Altitude: 0–1000 m **Annual rainfall:** 900–1600 mm
Typical local abundance: Frequent–occasional.
Vegetation: Rainforest e.g. with *Ceratopetalum apetalum, Doryphora sassafras;* rainforest margins, moist open-forest e.g. with *Eucalyptus pilularis, Syncarpia glomulifera, Eucalyptus smithii.*
Substrate: Clay soils on basalt, shale, gravelly alluvium.
Exposure: Full shade to mid-shade.

Conservation

Conservation: Conservation status unknown.

Olea europaea subsp. *africana* * OLEACEAE

Common Olive

Life history

Growth form: Much-branched tree 2–15 m high; lower surface of leaves green or yellowish brown.
Vegetative spread: No.
Longevity: Probably more than 100 years.
Primary juvenile period:
Flowers: Greenish white or cream, November–December.
Fruit/seed: Fleshy fruit 15–25 mm long, green turning black at maturity.
Dispersal, establishment & growth: Diaspore: fruit, vertebrate-adapted dispersal (Westoby et al. 1990). Fruit reported from pellets of Currawongs (Buchanan 1989a). Seedlings establish under isolated trees used by birds. Seedlings established under parent trees.
Fire response: Probably resprouts, though seedlings may be killed.
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to Africa and Asia, introduced as ornamental.
Botanical subregions: NC CC SC CWS; Vic., S.A.
Distribution Sydney area: Cumberland Plain.
Select locations: CC: Croydon (1893), St Marys, Coogee, Cambelltown, Camden, Razorback, Elderslie.

Habitat

Habitat: Dry hillsides.
Altitude: 0–300 m **Annual rainfall:** 700–1400 mm
Typical local abundance: Frequent–dominant.
Vegetation: Dry rainforest and grassy woodland e.g. *Eucalyptus moluccana, E. tereticornis, E. crebra.*
Substrate: Clay soil on Wianamatta Shale, particularly withy alkaline influence.
Exposure: Full sun to mid shade.

Conservation

Conservation: Major woody weed in dry rainforest and grassy woodland remnants in western Sydney, particularly in Campbelltown–Camden area on shale soils, forming dense thickets and crowding out other species. Isolated trees form focus for introduction by birds. Noted as a serious weed in 1960s, probably originally spreading from hedge plantings.

Epilobium billardierianum subsp. *billardierianum* ONAGRACEAE

Life history

Growth form: Erect stoloniferous perennial herb to 1 m high, with toothed leaves 6–18 mm wide.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Purplish pink or white, January–May.
Fruit/seed: Hairy capsule 3–7.5 mm long, with hairy seeds 1 mm long.
Dispersal, establishment & growth: Diaspore adapted for wind-dispersal (McIntyre et al. 1995).
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CC SC CT; Vic., Tas., S.A.
Distribution Sydney area: Coast south from Botany Bay.
Select locations: **CC:** Botany, Lady Robinsons Beach, La Perouse, Kurnell.

Habitat

Habitat: Clifflines.
Altitude: 0–50 m **Annual rainfall:** 1200–1400 mm
Typical local abundance: Occasional.
Vegetation: Coastal herbland e.g. with *Samolus repens, Baumea juncea.*
Substrate: Moist sandy soils, low nutrients.
Exposure:

Conservation

Conservation: Conservation status unknown, northern geographical limit is Botany.

Epilobium billardierianum subsp. *cinereum* ONAGRACEAE

Life history

Growth form: Erect stoloniferous perennial herb to 1 m high, with toothed leaves 6–18 mm wide.
Vegetative spread: Yes (McIntyre et al. 1995).
Longevity:
Primary juvenile period:
Flowers: Purplish pink or white, peaks February–March and November–December.
Fruit/seed: Hairy capsule 3–7.5 mm long, with hairy seeds 1 mm long, February–March, November–December..
Dispersal, establishment & growth: Diaspore adapted for wind-dispersal (McIntyre et al. 1995).
Fire response: Resprouted after high intensity fire (1/94) at Lane Cove; secondary juvenile period less than 3 months (P. Kubiak pers. comm.).
Interaction with other organisms: Foodplant for larvae of Grapevine Moth *Phalaenoides glycinae* (Common 1990).

Distribution

Status/origin: Native.
Botanical subregions: NC CC SC NT CT ST NWS CWS SWS SWP; LHI, Qld, Vic., Tas., S.A., W.A., N.Z.
Distribution Sydney area: Widespread but mainly Tablelands.
Select locations: **CC:** Hornsby, Carlingford, Bundeena, Campbelltown, Bulli, Albion Park.
CT: Winburndale, Ilford, Bathurst, Mt Victoria, Mt Werong, Moss Vale, Abercrombie Caves, Wombeyan Caves, Wingello.

Habitat

Habitat: Hillsides, gullies, creekflats.
Altitude: 0–1000 m **Annual rainfall:** 700–1200 mm
Typical local abundance: Occasional.
Vegetation: Open-forest e.g. with *Eucalytpus fastigata, E. viminalis*; woodland e.g. with *Eucalyptus macrorhyncha, E. bridgesiana, E. pauciflora, E. stellulata.*
Substrate: Clay soils on basalt, shale, Devonian sediments, granite, medium–high nutrients.
Exposure:

Conservation

Conservation: Probably adequately conserved.

Epilobium billardierianum subsp. *hydrophilum* ONAGRACEAE

Life history

Growth form: Erect stoloniferous perennial to 1 m high.
Vegetative spread: Yes (McIntyre et al. 1995).
Longevity:
Primary juvenile period:
Flowers: Purplish pink or white. January.
Fruit/seed: Hairy capsule 3–7.5 mm long, with hairy seeds 1 mm long.
Dispersal, establishment & growth: Diaspore adapted for wind-dispersal (McIntyre et al. 1995).
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC NT CT ST; Qld, Vic., Tas.
Distribution Sydney area: Tablelands.
Select locations: **CT:** Orange, Sunny Corner, Mt Wilson, Jenolan SF, Wombeyan Caves.

Habitat

Habitat: Moist sites, creekbanks.
Altitude: 600–1000 m **Annual rainfall:** 800–1400 mm
Typical local abundance: Occasional.
Vegetation: Open-forest e.g. with *Eucalyptus radiata, E. ovata.*
Substrate: Moist soil on Permian sediments, sometimes in running water
Exposure:

Conservation

Conservation: Conservation status unknown though habitat is vulnerable to weed invasion.

Epilobium ciliatum * ONAGRACEAE

Life history

Growth form: Erect herb to 2 m high
Vegetative spread: Leafy rosettes at base of stem produce their own root systems.
Longevity: Perennial but often behaves as an annual, relying on abundant seed (Preston 1988).
Primary juvenile period: 5.5 weeks (Preston 1988).
Flowers: Purplish pink or white, self-pollinated (Preston 1988).
Fruit/seed: Capsule 4–8 cm long, with numerous seeds 1 mm long. Seeds with tuft of hairs; can retain viability for several years (Preston 1988).
Dispersal, establishment & growth: Diaspore: seed, wind-dispersed (Preston 1988).
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to N America. A weed in nurseries (Herb. note).
Botanical subregions: CC CT ST; Qld, Vic., Tas., S.A., W.A.
Distribution Sydney area:
Select locations: **CC:** Ermington, Royal Botanic Gardens, Glenfield. **CT:** Mittagong.

Habitat

Habitat: Plant nurseries and propagation areas.
Altitude: 0–600 m **Annual rainfall:** 800–1200 mm
Typical local abundance: Frequent.
Vegetation:
Substrate: Nursery and potting media.
Exposure:

Conservation

Conservation: Naturalised in Sydney by 1930s (Preston 1988) as a weed in nurseries but does not appear naturalised into bushland; all records relate to horticultural situations.

Epilobium gunnianum ONAGRACEAE

Life history

Growth form: Erect perennial herb to 80 cm high.
Vegetative spread: Stoloniferous.
Longevity:
Primary juvenile period:
Flowers: Purplish pink, pale pink or white, January–April.
Fruit/seed: Capsule 3.5–7.5 cm long, with numerous seeds about 1 mm long, February–April.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CC SC NT CT ST; Vic., Tas., NZ.
Distribution Sydney area: Tablelands.
Select locations: CC: Cambewarra, Saddleback Mountain. **CT:** Mt Vincent, Clarence, Winburndale NR, Boyd Plateau, Wingcarribee Swamp, Tallong.

Habitat

Habitat: Creekbanks, swampy areas.
Altitude: 480–1200 m **Annual rainfall:** 700–1600 mm
Typical local abundance: Occasional.
Vegetation: Woodlands e.g. with *Eucalyptus radiata, E. mannifera, E. viminalis, E. pauciflora, E. dalrympleana, E. stellulata*; sedgeland e.g. with *Sphagnum, Geranium neglectum, Baloskion australe* (*Restio australis*).
Substrate: Peaty soil, moist or water up to 10 cm deep, clay soil on basalt, medium nutrients.
Exposure:

Conservation

Conservation: Conservation status unknown.

Epilobium hirtigerum ONAGRACEAE

Life history

Growth form: Robust, hairy perennial herb to more than 1 m high, often greyish.
Vegetative spread: Stoloniferous spread?
Longevity:
Primary juvenile period:
Flowers: Purplish pink, or white, November–February.
Fruit/seed: Hairy capsule 3.5–6 cm long, with numerous hairy seeds about 1 mm long, November–April.
Dispersal, establishment & growth: Diaspore adapted for wind-dispersal (McIntyre et al. 1995).
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CC SC NT CT ST CWS SWS SWP NFWP; Qld, Vic., Tas., S.A., W.A.
Distribution Sydney area: Widespread.
Select locations: CC: Gosford, Castle Hill, Cheltenham, Toongabbie, Glenbrook, Elderslie, Loftus, Appin, Seven Mile Beach. **CT:** Ilford, Blackmans Flat, Mt Victoria, Jenolan Caves, Kowmung Creek.

Habitat

Habitat: Creeks, swamps, sometimes disturbed sites.
Altitude: 0–1000 m **Annual rainfall:** 700–1400 mm
Typical local abundance: Frequent–occasional.
Vegetation: Woodland e.g. with *Eucalyptus resinifera, E. capitellata, E. dalrympleana, E. viminalis, E. macrorhyncha.*
Substrate: Clay soils on shale, alluvium, medium nutrients.
Exposure:

Conservation

Conservation: A native species able to cope with disturbed sites. Conservation status unknown.

Epilobium pallidiflorum ONAGRACEAE

Life history

Growth form: Erect, perennial herb to more than 1 m high.
Vegetative spread: Stoloniferous.
Longevity:
Primary juvenile period:
Flowers: Purplish pink, or white, February–April.
Fruit/seed: Hairy capsule 6.5–9.5 cm long, with numerous hairy seeds about 1 mm long, April.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CC SC CT ST; Vic., Tas., S.A., N.Z.
Distribution Sydney area: Localised.
Select locations: **CC:** Pagewood (1965–70). **CT:** Wingecarribee Swamp.

Habitat

Habitat: Swamp margins.
Altitude: 0–800 m **Annual rainfall:** 1200–1600 mm
Typical local abundance: Frequent.
Vegetation: Montane swamp e.g. with *Carex, Juncus, Phragmites australis.*
Substrate: Peaty or sandy soils, sometimes in standing water to 15 cm deep, low to high nutrients.
Exposure:

Conservation

Conservation: Sydney region is northern geographical limit, conservation status unknown. Probably extinct at Pagewood, reported from Wingecarribee Swamp in 1992.

Gaura lindheimeri * ONAGRACEAE

Life history

Growth form: Much branched perennial herb to 1.5 m high.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: White, becoming reddish or yellow.
Fruit/seed: Indehiscent, woody, nut-like, 6–8 mm long.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to America.
Botanical subregions: CC CT; S.A.
Distribution Sydney area: Camden district (Harden 1991).
Select locations:

Habitat

Habitat:
Altitude: 0–300 m **Annual rainfall:** 700 mm
Typical local abundance:
Vegetation:
Substrate:
Exposure:

Conservation

Conservation: Occasional garden escape, not invasive of bushland.

Ludwigia peploides subsp. *montevidensis* — ONAGRACEAE

Water Primrose

Life history

Growth form: Prostrate, often hairy perennial aquatic herb with creeping or floating stems to 4 m long, rooting at the nodes.
Vegetative spread: Creeping or floating stems root at nodes attached to soil or hanging in water (Sainty & Jacobs 1981).
Longevity: Indefinite, dies back in winter.
Primary juvenile period:
Flowers: Yellow, November–March, peak January.
Fruit/seed: Capsule 1–3 cm long, with numerous seeds 1 mm diam., January.
Dispersal, establishment & growth: Diaspore: seed and stem fragments, dispersed by water. Growth in summer.
Fire response:
Interaction with other organisms: Seeds a food source for water birds (Sainty & Jacobs 1988).

Distribution

Status/origin: Native.
Botanical subregions: NC CC SC NWS CWS SWS NWP SWP NFWP; Qld, Vic., S.A., N.Z., S Amer.
Distribution Sydney area: Coast and Western Sydney.
Select locations: CC: Narara, Centennial Park, Richmond (1804), Doonside, Glenfield, Regentville, Mount Annan, Dapto, Nowra.

Habitat

Habitat: Edges of lakes and streams, common in permanent water.
Altitude: 0–50 m **Annual rainfall:** above 800 mm
Typical local abundance: Frequent.
Vegetation: Open-water with *Eleocharis sphacelata, Paspalum distichum, Persicaria strigosa.*
Substrate: Creeping on mud or floating, able to survive dry conditions, medium–high nutrients. Water table mostly high–permanently high.
Exposure: Not in shade.

Conservation

Conservation: Conserved in Western Sydney (James et al. 1999). Conservation status elsewhere unknown.

Ludwigia peruviana * — ONAGRACEAE

Life history

Growth form: Hairy shrub to 3 m high, sometimes with pneumatophores arising from submerged or buried roots. Deciduous in winter in Sydney, with regrowth in spring; has a woody taproot with shallow laterals (Parsons & Cuthbertson 1992).
Vegetative spread: By layering of stems (C. Williams pers. comm.)
Longevity:
Primary juvenile period: About 2 years (Parsons & Cuthbertson 1992).
Flowers: Yellow, November–April.
Fruit/seed: Erect capsule 1–2 cm long, with numerous small seeds, mature February–October.
Dispersal, establishment & growth: Diaspore: seed. Seeds germinate readily in spring, in drying mud at edges of streams and swamps, on mats of floating vegetation, and in mud in shallow water (Parsons & Cuthbertson 1992).
Fire response: Resprouted after high intensity fire (1/94) at Narrabeen; secondary juvenile period 5 months (P. Kubiak pers. comm.).
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to S America. Probably introduced to Australia as a garden ornamental in ponds (Parsons & Cuthbertson 1992).
Botanical subregions: CC.
Distribution Sydney area: Widespread on coast.
Select locations: CC: Gosford (1984), Oxford Falls (1993), Frenchs Forest (1986), Manly Vale (1971), Little Bay (1999), Eastlakes (1971), Woronora River (1982), Heathcote Creek (1983), Smiths Creek Campbelltown (1991).

Habitat

Habitat: Creekbanks, swampy lake margins, still or slow-flowing water.
Altitude: 0–200 m **Annual rainfall:** 200–1400 mm
Typical local abundance: Frequent–dominant.
Vegetation: Riparian vegetation, generally disturbed e.g. with *Ligustrum sinense, Ageratina adenophora, Lantana camara.*
Substrate: Sandy alluvium, poorly drained, low–high nutrients.
Exposure:

Conservation

Conservation: First reported established in Botany Swamps–Eastlakes (1971) and has since spread to waterways north and south of Sydney, particularly nutrient-enriched creeks. Has the potential to spread to all Australian waterways, dominating wetlands and displacing native flora and fauna (Parsons & Cuthbertson 1992). Killed by chemical spraying, followed by burning; resprouts from swollen root after 'cut and paint' method (C. Williams pers. comm.).

Oenothera affinis * ONAGRACEAE

Life history

Growth form: Erect annual herb to 150 cm high.
Vegetative spread:
Longevity: 1 year.
Primary juvenile period: Less than 1 year.
Flowers: Yellow, becoming reddish, March.
Fruit/seed: A capsule 2–4 cm long, with numerous seeds.
Dispersal, establishment & growth: Prolific seeder and germinator, vegetative reproducer, dispersed by gravity or water (Anon 1991).
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to S America.
Botanical subregions: NC CC SC NWS CWS NWP; Qld, S.A., W.A.
Distribution Sydney area:
Select locations: CC: Kangy Angy (1970), Wondabyne (1922), Richmond (1970), Rockdale (1902).

Habitat

Habitat: River edges, roadsides, disturbed areas.
Altitude: 0–100 m **Annual rainfall:** 700–1200 mm
Typical local abundance:
Vegetation: Margins of forest e.g. with *Syncarpia glomulifera, Eucalyptus saligna.*
Substrate: Clay soil, medium nutrients.
Exposure: Full sun.

Conservation

Conservation: Widely cultivated and naturalised.

Oenothera drummondii * ONAGRACEAE

Life history

Growth form: Perennial herb to 60 cm high, with a basal rosette and strong taproot.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Yellow.
Fruit/seed: Densely hairy capsule 3–5 cm long, with numerous seeds.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to N America.
Botanical subregions: NC CC SC; LHI, Qld.
Distribution Sydney area:
Select locations: **CC:** Woolooware Bay (1980), Marayong (1969).

Habitat

Habitat:
Altitude: 0–100 m **Annual rainfall:** 700–1200 mm
Typical local abundance:
Vegetation:
Substrate:
Exposure:

Conservation

Conservation: Naturalised, chiefly north of Sydney.

Oenothera glazioviana * ONAGRACEAE

Life history

Growth form: Usually biennial to 100 cm high.
Vegetative spread:
Longevity: 2 years.
Primary juvenile period: Less than 2 years.
Flowers: Yellow, becoming reddish.
Fruit/seed: Capsule 2–3 cm long, with numerous seeds.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Exotic, probably native to N America. Widely cultivated and naturalised.
Botanical subregions: NC CC SC NT CT ST NWS CWS; Qld, Vic., Tas.
Distribution Sydney area:
Select locations: **CC:** Collaroy, Neutral Bay, Arncliffe, Blaxland. **CT:** Perthville, Hampton, Katoomba, Wentworth Falls.

Habitat

Habitat: Roadsides, railways, beaches.
Altitude: 0–1000 m **Annual rainfall:** 600–1200 mm
Typical local abundance: Rare–abundant.
Vegetation:
Substrate: Sandy soils on sandstone, beach sand, low nutrients.
Exposure: Full sun.

Conservation

Conservation: Minor weed of disturbed places.

Oenothera indecora subsp. *bonariensis* * ONAGRACEAE

Life history

Growth form: Erect annual herb to 60 cm high. hybridizes with *O. stricta*.
Vegetative spread:
Longevity: 1 year.
Primary juvenile period: Less than 1 year.
Flowers: Yellow, becoming reddish, October–January.
Fruit/seed: Hairy capsule 2–3 cm long, with numerous seeds, November–December.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to S America.
Botanical subregions: NC CC NWS CWS NWP; Qld, W.A.
Distribution Sydney area: Mainly coastal suburbs.
Select locations: CC: Ourimbah, Patonga Beach, Windsor, Narrabeen, Balgowlah, Eastlakes, La Perouse, Sans Souci, Menangle Park, Campbelltown.

Habitat

Habitat: Roadsides, beaches, disturbed sites.
Altitude: 0–50 m **Annual rainfall:** 700–1400 mm
Typical local abundance: Frequent–occasional.
Vegetation: Lawns, grassy verges.
Substrate: Sandy soil, low nutrients.
Exposure:

Conservation

Conservation: A minor weed of disturbed sites.

Oenothera longiflora * ONAGRACEAE

Life history

Growth form: Annual or biennial herb to 1 m high, with basal rosette.
Vegetative spread:
Longevity: 1–2 years.
Primary juvenile period:
Flowers: Yellow, becoming dark red, October–April.
Fruit/seed: Capsule 3–4 cm long, with numerous seeds.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms: Flowers after being eaten by cattle (Herb. note).

Distribution

Status/origin: Exotic, native to S America.
Botanical subregions: NC CC SWS.
Distribution Sydney area: Mainly Albion Park–Minnamurra.
Select locations: CC: Menangle (1893), Albion Park, Minnamurra River.

Habitat

Habitat: Creekbanks.
Altitude: 0–200 m **Annual rainfall:** 800–1400 mm
Typical local abundance: Frequent.
Vegetation:
Substrate: Sandy alluvial soil, medium nutrients.
Exposure:

Conservation

Conservation:

Oenothera mollissima * ONAGRACEAE

Life history

Growth form: Annual herb to 1 m high; stems often woody.
Vegetative spread:
Longevity: 1 year.
Primary juvenile period: Less than one year.
Flowers: Yellow, becoming reddish, August–May.
Fruit/seed: Hairy capsule 25 mm long, with numerous seeds.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to S America.
Botanical subregions: NC CC NWS NWP; Qld.
Distribution Sydney area:
Select locations: **CC:** St Huberts Island, Woy Woy (1969), Windsor, Mosman, Centennial Park, East Lakes, La Perouse, Minnamurra River.

Habitat

Habitat: Roadsides, footpaths.
Altitude: 0–100 m **Annual rainfall:** 700–1200 mm
Typical local abundance: Frequent–occasional.
Vegetation:
Substrate: Sandy soil.
Exposure:

Conservation

Conservation: Naturalised in disturbed sites. Possibly spreading.

Oenothera rosea * ONAGRACEAE

Life history

Growth form: Perennial shrub to 60 cm high.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Deep pink, November.
Fruit/seed: Hairy, ribbed capsule 5–7 mm long, with numerous seeds, mature November.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to America.
Botanical subregions: CC NT NWS; Qld, Vic.
Distribution Sydney area:
Select locations: **CC:** Windsor (1955), Killara (1994), Grose Vale (1910).

Habitat

Habitat: River edges.
Altitude: 0–200 m **Annual rainfall:** 900–1400 mm
Typical local abundance:
Vegetation: Roadside weeds including *Plantago lanceolata.*
Substrate:
Exposure:

Conservation

Conservation: Widely cultivated and occasionally naturalised. Earliest Sydney area record is for Gose Vale (1910) where it had been 'found on roadside for last 18 years..... gardens not far away but no sign of it spreading from any garden.' Subsequent records suggest it has not spread much. The Windsor and Killara sites may be separate introductions from gardens.

Oenothera speciosa * ONAGRACEAE

Life history

Growth form: Annual or perennial subshrub or herb to 50 cm high.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Pink or white.
Fruit/seed: Hairy, ribbed capsule 10–15 mm long, with numerous seeds.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to N America.
Botanical subregions: CC CWS NWP SWP; Vic.
Distribution Sydney area: Penrith.
Select locations: **CC:** Regentville, Penrith (1951).

Habitat

Habitat:
Altitude: 0–200 m **Annual rainfall:** 800 mm
Typical local abundance:
Vegetation:
Substrate:
Exposure:

Conservation

Conservation: Local population, probably garden escape rather than thoroughly naturalised (Herb. note).

Oenothera stricta * ONAGRACEAE

Life history

Growth form: Erect herb to 1 m high. Hybridizes with *O. indecora.*
Vegetative spread: No.
Longevity: 1–2 years.
Primary juvenile period:
Flowers: Yellow, becoming reddish, October–June.
Fruit/seed: Capsule 3–4 cm long, with numerous seeds, mature January–April.
Dispersal, establishment & growth: No particular morphology for dispersal (McIntyre et al. 1995).
Fire response:
Interaction with other organisms: Roots eaten by Sulphur-crested Cockatoo *Cacatua galerita*, seed eaten by Crimson Rosella *Platycercus elegans* (Lepschi 1993).

Distribution

Status/origin: Exotic, native to Chile and Argentina. Cultivated, sometimes naturalised.
Botanical subregions: NC CC SC NT CT ST NWS CWS SWS NWP SWP SFWP; Qld, Vic., Tas., N.T., S.A., W.A.
Distribution Sydney area: Widespread.
Select locations: **CC:** Wyong, Narrabeen Lake, Emu Plains, La Perouse, Bankstown, Casula. **CT:** Orange, Bathurst, Wentworth Falls, Medlow Bath, Jenolan Caves, Tallong.

Habitat

Habitat: Roadsides, drains, disturbed sites.
Altitude: 0–1000 m **Annual rainfall:** 700–1400 mm
Typical local abundance: Frequent.
Vegetation: Roadside sites e.g. with *Verbena bonariensis, Persicaria prostrata, Geranium* sp.
Substrate: Mostly sandy soils, but also on basalt.
Exposure:

Conservation

Conservation: Widely naturalised but appears to be confined to disturbed sites.

Oenothera tetraptera * ONAGRACEAE

Life history

Growth form: Perennial herb 15–50 cm high, with basal rosette.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: White or pink.
Fruit/seed: Hairy, ribbed capsule 10–15 mm long, with numerous seeds.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to tropical America. Cutivated and occasionally naturalised.
Botanical subregions: NC CC NT CWS; Qld.
Distribution Sydney area: Grose Vale.
Select locations: **CC:** Grose Vale (1910) only record.

Habitat

Habitat:
Altitude: 200 m **Annual rainfall:** 900 mm
Typical local abundance:
Vegetation:
Substrate:
Exposure:

Conservation

Conservation: Mainly recorded further north. Only one record for Sydney area, Grose Vale (1910). Current status unknown.

Oxalis articulata * OXALIDACEAE

Life history

Growth form: Herb with very short stem and woody rhizome 10 cm long; no bulb or bulbils.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Pink or purple, March–December, peak October.
Fruit/seed: Fruit not known in Australia (Harden 1992).
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to S America. Introduced as a garden plant.
Botanical subregions: NC CC SC NT CT ST CWS; Vic., Tas., S.A.
Distribution Sydney area: Widespread.
Select locations: **CC:** Lisarow, Parramatta, Coogee, Austinmer, Kangaroo Valley.
CT: Wentworth Falls, Orange, Bathurst, Hampton, Oberon, Mittagong, Yerranderie.

Habitat

Habitat: Roadsides, cemeteries, footpaths.
Altitude: 0–1000 m **Annual rainfall:** 600–1400 mm
Typical local abundance: Frequent–occasional.
Vegetation: Grassy areas.
Substrate: Clay soils.
Exposure:

Conservation

Conservation: Garden escape, local minor weed in disturbed open areas.

Oxalis bifurca * OXALIDACEAE

Life history

Growth form: Herb with very short stem; bulbs to 3 cm long, bulbils formed in old bulbs.
Vegetative spread: By bulbils.
Longevity: Indefinite.
Primary juvenile period:
Flowers: Pink to mauve, March–April.
Fruit/seed: Fruit not known in Australia (Harden 1992).
Dispersal, establishment & growth: Diaspore: bulb, dispersed in soil or garden refuse.
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to S Africa. Introduced as a garden plant.
Botanical subregions: CC.
Distribution Sydney area:
Select locations: **CC:** Campbelltown (1955–1994).

Habitat

Habitat: Cemetery.
Altitude: 0–100 m **Annual rainfall:** 700–800 mm
Typical local abundance: Frequent.
Vegetation:
Substrate: Clay soil on Wianamatta Shale.
Exposure:

Conservation

Conservation: Recorded only from St Peters Church of England Cemetery at Campbelltown where it was probably originally planted and has persisted since at least 1955.

Oxalis bowiei * OXALIDACEAE

Life history

Growth form: Herb with almost no stem; tapered bulb 1.5–4 cm long.
Vegetative spread: Spread by bulbs.
Longevity:
Primary juvenile period:
Flowers: Light pink with greenish yellow at base.
Fruit/seed: Fruit not known in Australia (Harden 1992).
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Exotic, native of S Africa. Introduced as ornamental.
Botanical subregions: CC CWS SWS SWP; S.A.
Distribution Sydney area:
Select locations: **CC:** Eastwood, Mount Druitt, Campbelltown.

Habitat

Habitat: Cemetery, gardens.
Altitude: 0–200 m **Annual rainfall:** 700–1200 mm
Typical local abundance: Occasional.
Vegetation: Disturbed woodland e.g. with *Eucalyptus moluccana, E. tereticornis.*
Substrate: Clay soils on shale, well-drained.
Exposure: Mid-shade.

Conservation

Conservation: A garden weed, persisting where planted or dumped but not truly naturalised.

Oxalis chnoodes OXALIDACEAE

Life history

Growth form: Herb with decumbent or creeping branches to 40 cm long; roots fibrous, no bulbs.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Yellow, September–April, peak November.
Fruit/seed: Capsule usually held above leaves, with ribbed seeds, mature September–May.
Dispersal, establishment & growth: Diaspore: seed, ballistic dispersal (Westoby et al. 1990).
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC CC CT ST NWS CWS NWP SWP NFWP SFWP; Qld, Vic., N.G. & Bismark Archipelago.
Distribution Sydney area:
Select locations: **CC:** Avoca Beach, Penrith, Razorback Mountain, Werrong Beach, Otford, Five Islands, Albion Park. **CT:** Barbers Creek.

Habitat

Habitat:
Altitude: 0–800 m **Annual rainfall:** 700–1400 mm
Typical local abundance: Occasional.
Vegetation: Rainforest, moist forest e.g. with *Eucalyptus pilularis, Syncarpia glomulifera.*
Substrate: Clay soils of shale, high–medium nutrients, also rocky slopes and screes.
Exposure:

Conservation

Conservation: Vulnerable in Western Sydney (James et al. 1999).

Oxalis corniculata * OXALIDACEAE

Creeping Oxalis

Life history

Growth form: Prostrate herb with branches sometimes creeping to 30 cm long.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Yellow, August–June, peak September.
Fruit/seed: Slender capsule 8–16 mm long, with ribbed seeds, mature August–June, peak September.
Dispersal, establishment & growth: Diaspore: seed. Dispersed in mud on cars (Wace 1977).
Fire response: Regrowth and suckers from rootstocks and lateral roots, seedlings recorded less than 1 year after fire (Purdie 1977), produced flowers after 10 weeks after high intensity fire (1/94) at Lane Cove (P. Kubiak pers. comm.).
Interaction with other organisms: Butterfly larvae *Lucia limbaria* usually feed on the plant during the day, attended by numerous small black ants, Iridomyrmex species, which excavate tunnels 5–6 cm deep in the soil at the base of the plant (Common & Waterhouse 1981).

Distribution

Status/origin: Exotic, probably native to Europe, cosmopolitan weed.
Botanical subregions: CC CT; Qld, Vic., Tas., N.T., S.A., W.A.
Distribution Sydney area: Widespread.
Select locations: **CC:** Kincumber, Blaxland, Hornsby, Penrith, Lane Cove, Balmain, Maroubra, Campbelltown, Stanwell Park, Shellharbour, Bomaderry. **CT:** Orange, Blackheath, Cambewarra Lookout, Mittagong, Penrose.

Habitat

Habitat: Gardens, parks, footpaths, lawns.
Altitude: 0–1000 m **Annual rainfall:** 700–1400 mm
Typical local abundance: Frequent.
Vegetation: Lawns, gardens, with introduced species.
Substrate: Sandy soils to clay soils.
Exposure: Full sun.

Conservation

Conservation: Weed, commonly naturalised in and around populated areas, often in gardens and parks.

Oxalis debilis var. *corymbosa* * OXALIDACEAE

Life history

Growth form: Herb, with reduced stem not easily seen; bulbs 1–3 cm long, with sessile bulbils formed from old bulbs.
Vegetative spread: By bulbils.
Longevity:
Primary juvenile period:
Flowers: Pink, August–May.
Fruit/seed: Fruit not known in Australia (Harden 1992).
Dispersal, establishment & growth: Diaspore: bulbils, remain dormant for long periods, withstanding extremes of drought and cold; seed not produced (Chancellor 1980).
Fire response: Probably resprouts. Flowered within 5 months after high intensity fire (1/94) at Lane Cove (P. Kubiak pers. comm.).
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to S America. Introduced as ornamental.
Botanical subregions: NC CC SC; Qld, Vic., N.T., S.A., W.A.
Distribution Sydney area: Sydney suburbs.
Select locations: **CC:** Beecroft, Northbridge, Summer Hill, Burwood, Government House (1902), Centennial Park, Picnic Point, Campbelltown, Balmain.

Habitat

Habitat: Gardens, roadsides.
Altitude: 0–200 m **Annual rainfall:** 700–1400 mm
Typical local abundance: Frequent–occasional.
Vegetation:
Substrate:
Exposure: Full sun.

Conservation

Conservation: A common garden weed, sometimes found in disturbed sites such as roadsides. Digging spreads bulblets, which should be burnt (Chancellor 1980).

Oxalis exilis OXALIDACEAE

Life history

Growth form: Procumbent tufted herb, with ascending or creeping branches to 35 cm long; no bulbs.
Vegetative spread: Possibly rooting at nodes (Herb. specimen).
Longevity:
Primary juvenile period:
Flowers: Yellow, October–May.
Fruit/seed: Capsule usually held above leaves, with ribbed seeds, mature October–May.
Dispersal, establishment & growth: Dispersal: ballistic (Westoby et al. 1990), no particular morphology for dispersal (McIntyre et al. 1995).
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC CC SC NT CT ST NWS CWS SWS; Vic., Tas., N.I., N Cal., N.Z.
Distribution Sydney area: Widespread.
Select locations: **CC:** Ourimbah, Cromer, Pymble, Lane Cove, Ashfield, Loftus, Kincumber, Nowra. **CT:** Orange, Blackheath, Abercrombie Caves, Yerranderie, Burradoo, Penrose.

Habitat

Habitat: Disturbed sites, bushland, gardens.
Altitude: 0–1000 m **Annual rainfall:** 700–1400 mm
Typical local abundance: Frequent–occasional.
Vegetation: Woodland e.g. with *Eucalyptus sclerophylla*; open-forest e.g. with *Eucalyptus paniculata, E. saligna* as well as grassland and garden beds.
Substrate: Sandy soils to clay soils.
Exposure:

Conservation

Conservation: Vulnerable in Western Sydney (James et al. 1999). Conservation status elsewhere unknown.

Oxalis incarnata * OXALIDACEAE

Life history

Growth form: Erect herb 5–25 cm high, with rhizome 3–8 cm long and bulbs1.5 cm long; bulbils form in leaf axils and on rhizome.
Vegetative spread: Yes
Longevity:
Primary juvenile period:
Flowers: White, pale mauve, or pale pinkish purple and greenish at base, September–April, peak October.
Fruit/seed: Fruit not known in Australia (Harden 1992).
Dispersal, establishment & growth: Diaspore: bulbils, spread in soil or garden refuse.
Fire response: Probably resprouted after high intensity fire (1/94) at Lane Cove, flowering in 4 months (P. Kubiak pers. comm.).
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to S Africa. Probably introduced as ornamental.
Botanical subregions: CC SC SWS; Vic., Tas., S.A., W.A.
Distribution Sydney area: Mainly coastal.
Select locations: **CC:** Hornsby, Beecroft, Cheltenham, Campbelltown, Austinmer, Yallah (1927). **CT:** Mittagong.

Habitat

Habitat: Roadsides, gardens, creeks.
Altitude: 0–600 m **Annual rainfall:** 700–1400 mm
Typical local abundance: Occasional.
Vegetation: Weedy vegetation e.g. with *Lantana camara, Ligustrum lucidum, Lonicera japonica, Tradescantia fluminensis.*
Substrate: Moist sites on sandy soils.
Exposure: Mid-shade.

Conservation

Conservation: Weed of gardens and roadsides.

Oxalis latifolia * OXALIDACEAE

Life history

Growth form: Herb, with reduced stem not easily seen; bulbs 1.5 cm long, bulbils formed from old bulbs on stolons 0.5–4 cm long.
Vegetative spread: Colonies increase in size and density from bulbils (Parsons & Cuthbertson 1992).
Longevity:
Primary juvenile period:
Flowers: Pink to purple, with white at base, December–June, peak April.
Fruit/seed: Fruit not developed in Australia (Harden 1992).
Dispersal, establishment & growth: Diaspore: bulb, spread by soil movement and by dumping of garden refuse. Bulbs produce leaves and stolons in autumn, and a thick carrot-like main taproot at the base of the bulb; after 6–8 weeks bulbils form at the base of the old bulb; flower stems are produced after 15–16 weeks (Parsons & Cuthbertson 1992).
Fire response: Possibly resprouts. Flowered within 2 months after high intensity fire (1/94) at Lane Cove (P. Kubiak pers. comm.).
Interaction with other organisms: Control is difficult; regular and frequent defoliation by mowing or use of chemicals is more effective at bulb exhaustion stage before bulbils are mature enough to survive (Parsons & Cuthbertson 1992).

Distribution

Status/origin: Exotic, native to Mexico. Introduced as ornamental.
Botanical subregions: NC CC CT NWS SWS; Vic., Tas., S.A., W.A.
Distribution Sydney area: Widespread.
Select locations: **CC:** Wahroonga, Turramurra, Strathfield, Hurstville, Campbelltown. **CT:** Orange, Lawson, Fitzroy Falls.

Habitat

Habitat: Gardens, roadsides and disturbed areas.
Altitude: 0–1000 m **Annual rainfall:** 700–1400 mm
Typical local abundance: Frequent.
Vegetation: Mainly in gardens.
Substrate: Garden soils on clay and basalt.
Exposure:

Conservation

Conservation: A weed of gardens, rarely reported from bushland, and then clumped and apparently dumped.

Oxalis perennans OXALIDACEAE

Life history

Growth form: Herb, sometimes creeping to 25 cm long, stout taproot; no bulbils.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Yellow, March to December.
Fruit/seed: Capsule usually held above the leaves, with ribbed seeds, mature at any time of year, peak November.
Dispersal, establishment & growth: Diaspore: seed.
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC CC CT ST NWS CWS NWP SWP NFWP SFWP; Qld, Vic., Tas., N.T., S.A., W.A., N.Z.
Distribution Sydney area: Widespread.
Select locations: **CC:** Gibber Swamp, Longneck Lagoon, Castlereagh NR, Hornsby, Long Reef, Lane Cove, Watsons Bay, Homebush, East Hills, Kurnell, Engadine, Silverdale, Razorback Mountain, Seven Mile Beach. **CT:** Blackheath, Orange, Katoomba, Cambewarra.

Habitat

Habitat: Disturbed sites, lawns, remnant bushland.
Altitude: 0–1000 m **Annual rainfall:** 700–1400 mm
Typical local abundance: Frequent–occasional.
Vegetation: Woodland e.g. with *Eucalyptus crebra, E. fibrosa, E. sclerophylla*; seacliffs with *Lomandra longifolia.*
Substrate: Clay soils on shale, Tertiary alluvium. Also rocky sites and sand dunes.
Exposure:

Conservation

Conservation: Vulnerable in Western Sydney (James et al. 1999). Conservation status elsewhere unknown.

Oxalis pes-caprae * OXALIDACEAE

Soursob

Life history

Growth form: Rhizomatous herb, with bulbs and bulbils, stem only developed when the plant is crowded or shaded.
Vegetative spread: By rhizome, bulb and bulbils.
Longevity:
Primary juvenile period:
Flowers: Yellow, May–November, peak August–September.
Fruit/seed: Fruit not known in Australia (Harden 1992).
Dispersal, establishment & growth: Diaspore: bulb or bulbil, spread by soil movement or dumping of garden refuse, and through nursery trade. Birds are responsible for some spread when they eat bulbs; shoots can emerge from bulbs buried up to 60 cm deep (Parsons & Cuthbertson 1992).
Fire response: Probably resprouted and flowered within 7 months after high intensity fire (1/94) at Lane Cove (P. Kubiak pers comm.).
Interaction with other organisms: Bulbils eaten by Stubble Quail *Coturnix pectoralis* (Barker & Vestjens 1989, 1990). Control more effective at bulb exhaustion stage; poisonous to sheep and cattle over time as oxalic acid content causes an accumulation of precipitates in brain and kidney tissue (Parsons & Cuthbertson 1992).

Distribution

Status/origin: Exotic, native to S Africa. Introduced as ornamental in Adelaide Botanic Gardens in 1841 (Parsons & Cuthbertson 1992).
Botanical subregions: NC CC SC NWS CWS SWS NWP SWP; Qld, Vic., N.T., S.A., W.A.
Distribution Sydney area: Sydney suburbs.
Select locations: CC: Lisarow, Cheltenham, Government House (1902), Glenfield, Ermington, Belmore, Liverpool, Tamarama.

Habitat

Habitat: Gardens, roadsides.
Altitude: 0–100 m **Annual rainfall:** 900–1400 mm
Typical local abundance: Frequent.
Vegetation: Gardens.
Substrate:
Exposure: Full sun.

Conservation

Conservation: Weed of gardens and roadsides. Rarely invades undisturbed plant communities (Parsons & Cuthbertson 1992). A more significant weed in South Australia (B. Briggs pers. comm.).

Oxalis purpurea * OXALIDACEAE

Life history

Growth form: Herb with very short stem; rhizome to 15 cm long and bulbs 1–3.5 cm long.
Vegetative spread: By rhizome.
Longevity:
Primary juvenile period:
Flowers: Pink–purple.
Fruit/seed: Fruit not known in Australia (Harden 1992).
Dispersal, establishment & growth: Diaspore: bulb, dispersed by soil movement and dumping of garden refuse.
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to S Africa. Introduced as ornamental.
Botanical subregions: CC SC SWS; Vic., S.A., W.A.
Distribution Sydney area:
Select locations: CC: Hornsby, Cheltenham, North Head, Oatley, Audley, Warrimoo, Albion Park.

Habitat

Habitat: Roadsides, cemeteries, lawns.
Altitude: 0–300 m **Annual rainfall:** 900–1400 mm
Typical local abundance: Frequent–occasional.
Vegetation:
Substrate: Sandy and clay soils.
Exposure:

Conservation

Conservation: Occasional weed of grassy areas, not aggressive.

Oxalis radicosa OXALIDACEAE

Life history

Growth form: Herb with erect, ascending, or creeping hairy branches to 30 cm long. Sometimes has a stout woody taproot.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Yellow, September–April.
Fruit/seed: Erect capsule 7–20 mm long, with ribbed seeds, mature October–November.
Dispersal, establishment & growth: No particular morphology for dispersal (McIntyre et al. 1995). V. Klapake (Herb. note 1991) suggested that it was possibly being spread about by grading machinery.
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC CC SC NT CT ST NWS CWS SWS NWP; Qld, Vic., N.T., S.A., Afr., Asia, Pac Is.
Distribution Sydney area: Widespread.
Select locations: **CC:** Pitt Town, Casula, Eastlakes, Loftus. **CT:** Blackheath, Jenolan Caves, Mittagong.

Habitat

Habitat:
Altitude: 0–1000 m **Annual rainfall:** 700–1400 mm
Typical local abundance: Occasional.
Vegetation: Floodplain forest e.g. with *Eucalyptus baueriana, E. botryoides, Angophora floribunda*; woodland e.g. with *Eucalyptus crebra, E. fibrosa, E. tereticornis*; open grassy areas.
Substrate: Sandy soil on alluvium.
Exposure:

Conservation

Conservation: Vulnerable in Western Sydney (James et al. 1999). Conservation status elsewhere unknown.

Oxalis rubens OXALIDACEAE

Life history

Growth form: Herb with erect or ascending branches to 35 cm long; roots fibrous, no bulbils.
Vegetative spread: No.
Longevity:
Primary juvenile period:
Flowers: Yellow, November– February.
Fruit/seed: Erect hairy capsule 15–18 mm long, with ribbed seeds, mature November–April.
Dispersal, establishment & growth: Dispore: seed.
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC CC SC; LHI, Qld, Vic., S.A., N.Z.
Distribution Sydney area: Mainly along coastline.
Select locations: **CC:** Lane Cove, Eastlakes, Maroubra, Long Bay, Breakfast Creek, Glenbrook, Five Islands, Windang Island, Minnamurra River.

Habitat

Habitat: Islands, headlands, sand dunes, steep gully slopes.
Altitude: 0–100 m **Annual rainfall:** 900–1400 mm
Typical local abundance: Occasional.
Vegetation: Rocky headlands e.g. with *Melaleuca nodosa, Melaleuca armillaris, Westringia fruticosa.*
Substrate: Sandy soils on sandstone.
Exposure:

Conservation

Conservation: Vulnerable in Western Sydney (James et al. 1999). Conservation status elsewhere unknown.

Oxalis thompsoniae OXALIDACEAE

Life history

Growth form: Prostrate or decumbent creeping herb with slender taproot to 4.5 mm diam. (Conn & Richards 1994).
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Yellow, November–March.
Fruit/seed: Erect hairy capsule 5.5–16 mm long, arranged in group of three, with dark purple- brown seeds, mature at any time.
Dispersal, establishment & growth: Readily colonises disturbed areas.
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native with close affinities to native species of this region but occurs in disturbed sites similar to many cosmopolitan species (Conn & Richards 1994).
Botanical subregions: NC CC SC CT ST NWS CWS NWP; Vic., S.A., N.Z.
Distribution Sydney area: Widespread.
Select locations: **CC:** Kincumber, Windsor, Lane Cove, Casula, Maroubra, Campbelltown, Waterfall, Bomaderry. **CT:** Bathurst, Orange, Mittagong, Penrose.

Habitat

Habitat: Disturbed areas e.g. gardens, lawns, parklands, footpaths, around stockyards and farm buildings.
Altitude: 0–900 m **Annual rainfall:** 600–1400 mm
Typical local abundance: Frequent.
Vegetation: Disturbed heath, woodland and grassland in damp areas or on margins of these communities.
Substrate: Sandy soils from sandstone to heavy, clay-rich soils from shale or slate. Low to high nutrients.
Exposure: Full sun.

Conservation

Conservation: Locally common in disturbed areas, not regarded as endangered (Conn & Richards 1994).

Argemone ochroleuca subsp. *ochroleuca* * PAPAVARACEAE

Mexican Poppy

Life history

Growth form: Erect, glaucous, several-stemmed prickly herb to 1.5 m high, with yellow sap (Parsons & Cuthbertson 1992).
Vegetative spread: No (Parsons & Cuthbertson 1992).
Longevity: 1 year.
Primary juvenile period: Less than 1 year.
Flowers: Creamy white to yellow, summer.
Fruit/seed: Spiny capsule 2–4 cm long, with numerous seeds.
Dispersal, establishment & growth: Dispore: seed. Seeds dormant when shed, germinating after a few weeks to several months at any time of year if moisture is available; a rosette is formed during winter, flowering stems in spring, with flowering during summer (Parsons & Cuthbertson 1992).
Fire response: Probably killed.
Interaction with other organisms: Toxic to animals including humans and birds; contamination of food or cooking oil by seed or Argemone oil is believed to cause dropsy and glaucoma in humans (Parsons & Cuthbertson 1992).

Distribution

Status/origin: Exotic, native to America. Weed of cultivation.
Botanical subregions: NC CC SC NT CT ST NWS CWS SWS NWP SWP NFWP SFWP; Qld, Vic., N.T., S.A.
Distribution Sydney area: Widespread.
Select locations: **CC:** Hornsby, Cheltenham, Faulconbridge, Nepean & Warragambi Rivers (1886), Campbelltown, Thirlmere, Shellharbour. **CT:** Rockley.

Habitat

Habitat: Waste areas, roadsides, railways, paddocks.
Altitude: 0–1000 m **Annual rainfall:** 700–1400 mm
Typical local abundance:
Vegetation:
Substrate: Sandy alluvium. Recorded on saline sites in western NSW (Semple 1993).
Exposure: Full sun.

Conservation

Conservation: Widespread weed of cultivation.

Eschscholzia californica * PAPAVERACEAE

Californian Poppy

Life history

Growth form: Erect annual herb to 50 cm high.
Vegetative spread: No.
Longevity: 1 year.
Primary juvenile period: Less than 1 year.
Flowers: Yellow to bright orange, October–March.
Fruit/seed: Capsule 6–9 cm long, with numerous seeds.
Dispersal, establishment & growth:
Fire response: Probably killed.
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to America. Introduced as ornamental.
Botanical subregions: CT ST NWS CWS SWS; Vic., S.A.
Distribution Sydney area:
Select locations: **CC:** Richmond (1902), Campbelltown. **CT:** Lithgow, Mount Victoria, Medlow Bath.

Habitat

Habitat: Railway embankments, wasteland.
Altitude: 0–1000 m **Annual rainfall:** 700–1200 mm
Typical local abundance: Frequent.
Vegetation:
Substrate: Embankments.
Exposure: Full sun.

Conservation

Conservation: Widely cultivated, sometimes naturalised. Minor weed.

Papaver aculeatum PAPAVERACEAE

Native Poppy

Life history

Growth form: Erect annual herb to 40 cm high.
Vegetative spread: No.
Longevity: Less than 1 year.
Primary juvenile period:
Flowers: Red.
Fruit/seed: Capsule 15 mm long, with numerous seeds, December.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Doubtfully native. Widespread weed in cultivation and native plant communities (Harden 1990).
Botanical subregions: NC CC ST NWS CWS NWP SWP NFWP SFWP; Qld, Vic., Tas., S.A., S Afr.
Distribution Sydney area:
Select locations: **CC:** Lower Budgong.

Habitat

Habitat: Riverbank.
Altitude: 0–50 m **Annual rainfall:** 1200 mm
Typical local abundance:
Vegetation:
Substrate: Sandy alluvium.
Exposure:

Conservation

Conservation: Only one record for Sydney area at Lower Budgong, north-west of Nowra, recorded in 1939. Conservation status unknown.

Papaver dubium * PAPAVERACEAE

Longhead Poppy

Life history

Growth form: Herb to 1 m high.
Vegetative spread: No.
Longevity: 1 year.
Primary juvenile period: Less than1 year.
Flowers: Red, October–December, flowers last 1 day before being shed (A. N. Rodd Herb. specimen).
Fruit/seed: Cylindrical–oblong capsule 15–25 mm long, with numerous seeds, probably wind- gravity-dispersed, October–December.
Dispersal, establishment & growth: Diaspore: seed, probably wind- gravity-dispersed.
Fire response: Probably killed.
Interaction with other organisms: Suspected of poisoning stock (Cunningham et al. 1981).

Distribution

Status/origin: Exotic, native to Europe.
Botanical subregions: CC NT CT ST NWP SWP NFWP SFWP; S.A.
Distribution Sydney area: Widespread.
Select locations: **CC:** Glebe, Casula. **CT:** Orange, Moss Vale.

Habitat

Habitat: Roadsides, railways.
Altitude: 0–1000 m **Annual rainfall:** 700–1200 mm
Typical local abundance:
Vegetation:
Substrate:
Exposure:

Conservation

Conservation: Widespread, common minor weed.

Papaver hybridum * PAPAVERACEAE

Rough Poppy

Life history

Growth form: Erect annual hairy herb to 50 cm high, with milky sap.
Vegetative spread: No.
Longevity: 1 year.
Primary juvenile period: Less than 1 year.
Flowers: Crimson with a purplish blotch at base of petals, October–November.
Fruit/seed: Ribbed capsule with bristles; seeds numerous, October–November.
Dispersal, establishment & growth: Diaspore: seed.
Fire response:
Interaction with other organisms: Rarely eaten by stock due to offensive odour and taste but reported to cause disorders in stock when large quantities consumed in hay (Cunningham et al. 1981).

Distribution

Status/origin: Exotic, native to Europe.
Botanical subregions: NC CC SC CT ST NWS SWS NWP SWP NFWP SFWP; Vic., N.T., S.A., W.A.
Distribution Sydney area:
Select locations: **CC:** Putty (1902), Richmond, Chatswood, Flemington, Cooks River, Yellow Rock.

Habitat

Habitat: Gardens, roadsides, saleyards, waste areas.
Altitude: 0–1000 m **Annual rainfall:** 700–1200 mm
Typical local abundance: Frequent–occasional.
Vegetation:
Substrate: Clay soils on shale, basalt.
Exposure: Full sun.

Conservation

Conservation: Widespread minor weed.

Papaver somniferum subsp. ***setigerum*** * **PAPAVERACEAE**

Opium Poppy

Life history

Growth form: Glaucous annual herb to about 1 m high. Robust hollow stem; taproot with many branching laterals (Parsons & Cuthbertson 1992).
Vegetative spread: No.
Longevity: 12 months.
Primary juvenile period: 6–8 months.
Flowers: Pink with a purple spot at the base of the petals, October–November.
Fruit/seed: Roundish dehiscent capsule usually less than 2 cm diam., with numerous minute seeds, released from pores, November–December.
Dispersal, establishment & growth: Diaspore: seed, dispersed short distance by gravity, wind and water, or long distance in mud sticking to animals or machinery; germinates in autumn and early winter, producing a rosette of leaves; stems are produced in early spring and flowers in October and November, with flowering continuing while moisture is available; plants die in autumn (Parsons & Cuthbertson 1992).
Fire response:
Interaction with other organisms: Potentially toxic to stock if grazed in large quantities (Cunningham et al. 1981). Source of many drugs used in medicine; weed control by prevention of seeding — potential biological control with curculionid weevils, a root parasite and fungus (Parsons & Cuthbertson 1992).

Distribution

Status/origin: Exotic, native to Asia and Europe. Cultivated as an ornamental.
Botanical subregions: CC CT ST NWS CWS SWS NWP SWP NFWP SFWP; Vic., S.A., N.T.
Distribution Sydney area: Widespread.
Select locations: **CC:** Peats Ridge, Parramatta, Leichhardt, Ingleburn, Campbelltown, Douglas Park. **CT:** Orange, Wallerawang, Moss Vale.

Habitat

Habitat: Roadsides, embankments, riverbanks.
Altitude: 0–1000 m **Annual rainfall:** 700–1400 mm
Typical local abundance: Frequent–occasional.
Vegetation: With weeds of disturbance, pasture grasses.
Substrate: Sandy alluvium, disturbed rock, rubble and subsoil.
Exposure: Full sun.

Conservation

Conservation: Weed of cultivation.

Papaver somniferum subsp. *somniferum* * PAPAVERACEAE

Opium Poppy

Life history

Growth form: Glaucous annual herb to about 1 m high. Robust stem hollow; taproot with many branching laterals (Parsons & Cuthbertson 1992).
Vegetative spread: No.
Longevity: 1 year.
Primary juvenile period: Less than 1 year.
Flowers: Pink with a purple spot at the base, November–December.
Fruit/seed: Indehiscent capsule to 5 cm diam., with numerous minute seeds.
Dispersal, establishment & growth: Diaspore: seed, dispersed short distance by gravity, wind and water, or long distance in mud sticking to animals or machinery; germinates in autumn and early winter, producing a rosette of leaves; stems are produced in early spring and flowers in October and November, with flowering continuing while moisture is available; plants die in autumn (Parsons & Cuthbertson 1992).
Fire response:
Interaction with other organisms: Source of many drugs used in medicine (Parsons & Cuthbertson 1992) and 'poppy seed'.

Distribution

Status/origin: Exotic, native to Asia and Europe. Cultivated as an ornamental.
Botanical subregions: CC ST NWS CWS.
Distribution Sydney area:
Select locations: **CC:** Yarramundi, Parramatta, Everleigh, Cobbity, Macquarie Pass.

Habitat

Habitat: Roadsides, railways, disturbed sites.
Altitude: 0–200 m **Annual rainfall:** 700–1400 mm
Typical local abundance: Rare.
Vegetation:
Substrate: Clay soils.
Exposure:

Conservation

Conservation: Rare weed of cultivation, occasionally naturalised. Controlled by prevention of seeding — potential biological control with curculionid weevils, a root parasite and fungus (Parsons & Cuthbertson 1992).

Passiflora caerulea * PASSIFLORACEAE

Blue Passionflower

Life history

Growth form: Glabrous climber, with mostly 5-lobed leaves and axillary tendrils. A vigorous climber with long wiry stems and leathery leaves (Jones & Gray 1988).
Vegetative spread: By climbing stems.
Longevity:
Primary juvenile period:
Flowers: Greenish white and bluish or purplish, December.
Fruit/seed: Yellow to orange berry 6 cm long.
Dispersal, establishment & growth: Diaspore: fruit. Grows easily from cuttings (Jones & Gray 1988), possibly dispersed from dumped prunings.
Fire response:
Interaction with other organisms: Sometimes used as rootstock for commercial selections (Jones & Gray 1988).

Distribution

Status/origin: Exotic, native to Brazil. Sometimes cultivated as an ornamental.
Botanical subregions: CC SC CT NWP; Qld, W.A.
Distribution Sydney area: Sporadic.
Select locations: **CC:** Wongawilli (West Dapto), Epping. **CT:** Leura (1923).

Habitat

Habitat: Disturbed sites.
Altitude: 0–1000 m **Annual rainfall:** 1100–1600 mm
Typical local abundance: Rare.
Vegetation: Disturbed rainforest
Substrate: Clay soils on shale, medium nutrients.
Exposure: Tolerant of frosts (Jones & Gray 1988).

Conservation

Conservation: Occasionally naturalised in disturbed sites.

Passiflora cinnabarina PASSIFLORACEAE

Red Passionflower

Life history

Growth form: Slender glabrous climber with leaves usually 3-lobed, and axillary tendrils.
Vegetative spread: By climbing stems.
Longevity:
Primary juvenile period:
Flowers: Red, greenish on underside of petals, August–January.
Fruit/seed: Greenish-grey berry 2 cm long, December–January.
Dispersal, establishment & growth: Diaspore: fruit. Germination from fresh seed; cuttings strike readily (Jones & Gray 1988).
Fire response:
Interaction with other organisms: Fruit of native Passionfruit species eaten by Grey-headed Flying Fox *Pteropus poliocephalus* (Eby 1995).

Distribution

Status/origin: Native.
Botanical subregions: CC SC NT CT ST CWS SWS; Vic.
Distribution Sydney area: Mainly Illawarra and Upper Blue Mountains.
Select locations: **CC:** Yerranderie, Macquarie Pass, Cambewarra Mountain, Kangaroo Valley, Minnamurra Falls. **CT:** Mt Pomany, Mt Tomah, Jenolan Caves.

Habitat

Habitat: Coast and ranges.
Altitude: 0–1000 m **Annual rainfall:** 900–1600 mm
Typical local abundance: Occasional.
Vegetation: Open-forest e.g. with *Eucalptus fastigata, E. blaxlandii, E. radiata, E. punctata, E. sieberi.*
Substrate: Edge of basalt areas, medium-nutrient soils, well-drained.
Exposure: Partial sun, tolerant of frosts (Jones & Gray 1988).

Conservation

Conservation: Relatively rare species, conservation status unknown.

Passiflora edulis * PASSIFLORACEAE

Common Passionfruit

Life history

Growth form: Glabrous climber with axillary tendrils; leaves usually deeply 3-lobed.
Vegetative spread: By climbing stems.
Longevity:
Primary juvenile period: Fruited in 2.8 years after high intensity fire (1/94) at Lane Cove (P. Kubiak pers. comm.).
Flowers: White, tinged with purple.
Fruit/seed: Purple berry 3–4 cm diam., with edible pulp.
Dispersal, establishment & growth: Diaspore: fleshy fruit, vertebrate-adapted for dispersal (Westoby et al. 1990).
Fire response: Probably killed.
Interaction with other organisms: Foodplant of Grey Teal *Anas gibberifrons* (Barker & Vestjens 1989,1990). Bug ?Scolypopa australis (Ricaniidae) seen on the stem (P. Kubiak pers. comm.). Food plant of butterfly larvae *Acraea andromacha andromacha* (Common & Waterhouse 1981).

Distribution

Status/origin: Exotic, native to America. Widely cultivated for edible fruit.
Botanical subregions: NC CC; Qld, N.G., Pac Is.
Distribution Sydney area: Coastal.
Select locations: CC: Wyong, Pymble, Cheltenham, Casula, Otford, Wollongong, Kangaroo Valley.

Habitat

Habitat: Margins of rainforest, moist gullies, or other areas with high rainfall.
Altitude: 0–200 m **Annual rainfall:** 1200–1600 mm
Typical local abundance: Occasional.
Vegetation: Moist forest e.g. with *Eucalyptus saligna.*
Substrate: Clay soils on shale, basalt, medium to high nutrients.
Exposure: Full sun to medium shade. Tolerant of frost (Jones & Gray 1988).

Conservation

Conservation: Locally naturalised in moist forest.

Passiflora filamentosa * PASSIFLORACEAE

Life history

Growth form: Slender trailer with hairy stems and axillary tendrils; leaves sometimes hairy, mosty 5-lobed.
Vegetative spread: By trailing stems.
Longevity:
Primary juvenile period:
Flowers: Greenish white, banded with blue, November–March.
Fruit/seed: Berry 4 cm long, does not set seed in Australia (Harden 1990).
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to America.
Botanical subregions: CC NWS SWP.
Distribution Sydney area:
Select locations: CC: Camden (1965–1983).

Habitat

Habitat: Cemetery.
Altitude: 0–100 m **Annual rainfall:** 700 mm
Typical local abundance: Frequent.
Vegetation: Graves and non-mown areas.
Substrate: Clay soil on shale.
Exposure:

Conservation

Conservation: Reported naturalised at Camden cemetery 1965–1983. Potential to spread elsewhere unknown.

Passiflora herbertiana subsp. ***herbertiana*** **PASSIFLORACEAE**

Native Passionfruit

Life history

Growth form: Climber with hairy leaves and axillary tendrils.
Vegetative spread: By climbing stems.
Longevity: A few years (Jones & Gray 1988).
Primary juvenile period:
Flowers: Yellow to orange, all year, peak July–September.
Fruit/seed: Green spotted berry 5 cm long. Ripens sporadically (Jones & Gray 1988).
Dispersal, establishment & growth: Diaspore: fruit. Germination of fresh seed; cuttings strike readily (Jones & Gray 1988).
Fire response: Probably resprouted after high intensity fire (1/94) at Lane Cove; secondary juvenile period less than 2.5 years (P. Kubiak pers. comm.).
Interaction with other organisms: Fruit of native Passionfruit species eaten by Grey-headed Flying Fox *Pteropus poliocephalus* (Eby 1995). Honeybees feed on nectar; small black ants feed on petiolar glands near base of leaf (P. Kubiak pers. comm.). Extensive plant in Royal Botanic Gardens virtually defoliated by black caterpillars 3 cm long on 6/1/86.

Distribution

Status/origin: Native.
Botanical subregions: NC CC SC NT CT; Qld.
Distribution Sydney area: Coast, adjacent plateaus, lower Blue Mountains.
Select locations: CC: Wyong, Gosford, Wisemans Ferry, Kurrajong, Wheeny Creek, Bilpin, Cheltenham, Nortons Basin, Razorback, Douglas Park, Otford.

Habitat

Habitat: Moist forest on coast and ranges.
Altitude: 0–400 m **Annual rainfall:** 700–1600 mm
Typical local abundance: Frequent–occasional.
Vegetation: Moist forests e.g. with *Eucalyptus pilularis, Syncarpia glomulifera, Eucalyptus saligna, E. deanei, E. acmenoides, E. paniculata.*
Substrate: Sandy alluvium, medium–high nutrient soils. Good supply of water, well-drained (Jones & Gray 1988).
Exposure: Filtered sunlight, tolerant of frost (Jones & Gray 1988).

Conservation

Conservation: Vulnerable in Western Sydney (James et al. 1999). Conservation status elsewhere unknown.

Passiflora mollissima * PASSIFLORACEAE

Banana Passionfruit

Life history

Growth form: Climber with hairy stems and petioles, and axillary tendrils; leaves deeply 3-lobed.
Vegetative spread: By climbing stems.
Longevity:
Primary juvenile period:
Flowers: Pink.
Fruit/seed: Yellow berry 7 cm long, with edible pulp.
Dispersal, establishment & growth: Diaspore: fruit.
Fire response:
Interaction with other organisms: Food plant of butterfly larvae *Acraea andromacha andromacha* (Common & Waterhouse 1981).

Distribution

Status/origin: Exotic, native to Andes Mountains. Introduced as an ornamental.
Botanical subregions: NC CC; Qld, Vic.
Distribution Sydney area:
Select locations: **CC:** Kurrajong Heights, Springwood (1967), Glenfield, Mt Keira.

Habitat

Habitat: Moist gullies.
Altitude: 0–500 m **Annual rainfall:** 1000–1400 mm
Typical local abundance: Frequent.
Vegetation: Weedy areas, rainforest edges.
Substrate: Clay soils on shales, medium nutrients.
Exposure: Full sun to light shade.

Conservation

Conservation: Cultivated for showy flowers and edible fruit. Rarely naturalised in NSW (Harden 1990). Naturalised in cooler parts of Victoria and NSW, clambering to tops of large trees and smothering surrounding vegetation (Jones & Gray 1988). Potential invader of native vegetation (L.McD.).

Passiflora morifolia * PASSIFLORACEAE

Life history

Growth form: Twiner with scattered hairs on young stems and leaves; leaves usually 3-lobed, with axillary tendrils.
Vegetative spread: By twining stems.
Longevity:
Primary juvenile period:
Flowers: White, banded with purple or blue.
Fruit/seed: Deep purple berry 2 cm diam.
Dispersal, establishment & growth: Diaspore: fruit.
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to America. Introduced as ornamental.
Botanical subregions: CC.
Distribution Sydney area:
Select locations: **CC:** Milperra (1992).

Habitat

Habitat: Near habitation.
Altitude: 0–20 m **Annual rainfall:** 900–1000 mm
Typical local abundance: Frequent.
Vegetation: Floodplain forest e.g. with *Eucalyptus baueriana.*
Substrate: Sandy alluvium, medium nutrients.
Exposure:

Conservation

Conservation: Occasionally naturalised near habitation, weed potential unknown.

Passiflora suberosa * PASSIFLORACEAE

Cork Passionflower, Small Passionfruit

Life history

Growth form: Slender vine with corky older stems and axillary tendrils; leaves usually deeply lobed.
Vegetative spread: By climbing stems.
Longevity:
Primary juvenile period:
Flowers: Pale greenish, February–March.
Fruit/seed: Purple-black berry 15 mm diam., February–March.
Dispersal, establishment & growth: Diaspore: fruit.
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to S America. Introduced as an ornamental.
Botanical subregions: NC CC; Qld, N.T.
Distribution Sydney area:
Select locations: CC: Eastwood (1966), RBG Sydney.

Habitat

Habitat:
Altitude: 0–50 m **Annual rainfall:** 1100–1200 mm
Typical local abundance: Rare.
Vegetation: Garden.
Substrate: Cultivated soil.
Exposure:

Conservation

Conservation: Sometimes cultivated. Occasionally naturalised in gardens.

Passiflora subpeltata * PASSIFLORACEAE

White Passionflower

Life history

Growth form: Glabrous climber with axillary tendrils; leaves usually 3-lobed.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: White, tinged with green, November–April.
Fruit/seed: Green berry 4 cm long; not edible.
Dispersal, establishment & growth: Diaspore: fruit.
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to Brazil. Introduced as ornamental.
Botanical subregions: NC CC SC CWS; Qld, Vic.
Distribution Sydney area: Coast, particularly Illawarra.
Select locations: CC: Eastwood, Ingleburn, Royal NP, Camden, Menangle, Austinmer, Otford, Mt Kembla, Jamberoo, Macquarie Pass.

Habitat

Habitat: Disturbed moist forest sites.
Altitude: 0–200 m **Annual rainfall:** 700–1200 mm
Typical local abundance: Frequent.
Vegetation: Margins of coastal rainforest and moist open-forest.
Substrate: Clay soils on shale, medium–high nutrients.
Exposure:

Conservation

Conservation: Weed of coastal moist forest areas, gradually spreading since early 1900s.

Peperomia blanda var. *floribunda* PEPEROMIACEAE

Life history

Growth form: Succulent herb to 30 cm high, erect–decumbent, rooting at nodes (Forster 1993).
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Small, without sepals and petals.
Fruit/seed: Sticky, papillate drupe, 0.8–0.9 mm long; seeds noticeably sticky — mucilaginous substance around the papillate protuberances may aid in wide dispersal (Forster 1993).
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native. Widely distributed in Africa, India, Malesia and Melanesia (Forster 1993).
Botanical subregions: NC CC; Qld, Pac Is.
Distribution Sydney area: Coastal.
Select locations: CC: Olney SF, West Gosford, Long Island NR (L.McD.), Cowan, Neilson Park, Razorback, Albion Park.

Habitat

Habitat: Usually on rocks, or terrestrial.
Altitude: 0–300 m **Annual rainfall:** 700–1200 mm
Typical local abundance: Occasional.
Vegetation: Dry rainforest.
Substrate: On rocks, sandstone, 'calcareous' sandstone. Can stand drier conditions than other *Peperomia* species (Forster 1993).
Exposure: Semi-shade.

Conservation

Conservation: Southern geographical limit is Albion Park but conservation status in Sydney region unknown. Well conserved in south-east Queensland (Forster 1993).

Peperomia tetraphylla PEPEROMIACEAE

Life history

Growth form: Succulent herb to 10 cm high, stems erect–decumbent, rooting at nodes (Forster 1993).
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Small, without sepals and petals.
Fruit/seed: Smooth, sticky drupe 1 mm long (Forster 1993).
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native. Widely distributed in Africa, Malesia (Forster 1993).
Botanical subregions: NC CC SC ?NT CT ST; LHI, Qld, NZ, Pac; Is, Asia, Afr.
Distribution Sydney area: Mainly coast.
Select locations: CC: West Gosford, Burralow Creek, Stanwell Park, Mt Kembla, Albion Park, Minnamurra Falls, Bomaderry Creek. **CT:** Jenolan Caves, Kanangra.

Habitat

Habitat: On rocks, moist situations in rainforest.
Altitude: 0–1000 m **Annual rainfall:** 1100–1600 mm
Typical local abundance: Rare–occasional.
Vegetation: Wetter rainforest e.g. with *Ceratopetalum apetalum, Eupomatia laurina, Backhousia myrtifolia.*
Substrate: Moss-covered rocks, sandstone.
Exposure: Semi-shade.

Conservation

Conservation: In Eastern Australia, populations tend to be disjunct and restricted to wetter rainforest, not threatened (Forster 1993), though vulnerable to degradation of habitat by weed invasions.

Phytolacca octandra * PHYTOLACCACEAE

Inkweed

Life history

Growth form: Herb 1–2 m high, often woody at base, stems and inflorescences green to pinkish.
Vegetative spread:
Longevity: 1–3 years.
Primary juvenile period: 5 months.
Flowers: Green to pinkish, December–August.
Fruit/seed: 8-lobed berry 4–6 mm diam., red turning black when ripe, with 8 seeds, December–August.
Dispersal, establishment & growth: Diaspore: berry, bird-dispersed, fruit reported from pellets of Currawongs (Buchanan 1989a). Soil-stored seedbank, seeds germinate very poorly unless heated (Floyd 1966).
Fire response: Seedlings grew vigorously after high-intensity fire at Katandra 1994, fruiting 5 months after fire (L.McD.).
Interaction with other organisms: Fruits eaten by Brown Pidgeon at Berrilee (J. Howell 6.93 pers. comm.). Seeds eaten by Yellow-throated Scrubwren *Sericornis citreogularis* (Barker & Vestjens 1989,1990). Small black ants feed on nectar (P. Kubiak pers. comm.).

Distribution

Status/origin: Exotic, native to tropical America.
Botanical subregions: NC CC SC NT CT NWS CWS NWP SWP; Qld, Vic., S.A., W.A., N.T.
Distribution Sydney area: Widespread.
Select locations: **CC:** Kenthurst, Cheltenham, Mascot, Strathfield, Grose Vale, Campbelltown, Thirlmere, Austinmer, Mt Keira, Kiama, Cambewarra Range. **CT:** Bathurst, Mt Wilson, Kanangra, Robertson.

Habitat

Habitat: Disturbed sites, creeks.
Altitude: 0–1000 m **Annual rainfall:** 700–1400 mm
Typical local abundance: Frequent–occasional.
Vegetation: Disturbed sites in moist eucalypt forest and rainforest.
Substrate: Clay soils on shale, sandy alluvium, medium to high nutrients.
Exposure: Full sun to light shade.

Conservation

Conservation: Weed of disturbed sites.

Piper novae-hollandiae PIPERACEAE

Giant Pepper Vine

Life history

Growth form: Large glabrous climber, with adventitious roots.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Separate male and female flowers, August.
Fruit/seed: Fleshy fruit 5 mm long, October–December.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC CC SC NT; Qld.
Distribution Sydney area: Coast.
Select locations: **CC:** Peats Ridge, Austinmer, Bulli Pass, Mt Keira, Albion Park, Kiama, Cambewarra,

Habitat

Habitat: Coastal rainforest, steep slopes.
Altitude: 0–100 m **Annual rainfall:** 1200–1600 mm
Typical local abundance: Frequent.
Vegetation: Dry subtopical rainforest e.g. with *Cassine australis, Elaeocarpus kirtonii, Dendrocnide excelsa, Diospyros australis, Polyscias elegans.*
Substrate: Clay soils on basalt.
Exposure:

Conservation

Conservation: Conservation status unknown.

Billardiera scandens var. *scandens* PITTOSPORACEAE

Appleberry, Snotberry, Apple Dumplings

Life history

Growth form: Climber or scrambler with twining stems to 3 m long; leaves linear to ovate with lower surface glabrous or more or less hairy. The varieties intergrade in NSW and are sometimes difficult to identify satisfactorily.
Vegetative spread: No (McIntyre et al. 1995).
Longevity:
Primary juvenile period:
Flowers: Cream to greenish-yellow, most of the year, peak September–November.
Fruit/seed: Cylindrical berry 10–40 mm long, weight about 880 mg, with about 70 seeds per fruit enclosed in mucilaginous pulp (extra data on seed & pulp characteristics in French 1991), September–May.
Dispersal, establishment & growth: Diaspore: fruit, adapted for dispersal by ingestion (McIntyre et al. 1995), vertebrate-adapted (Westoby et al. 1990).
Fire response: Resprouts at base or below from surviving rootstocks (Fox 1988), seedlings recorded less than 1 year after fire (Purdie 1977). Secondary juvenile period 1.9 years after high intensity fire (1/94) at Lane Cove (P. Kubiak pers. comm.).
Interaction with other organisms: Eaten by rabbits (P. Kubiak pers. comm.).

Distribution

Status/origin: Native.
Botanical subregions: NC CC SC NT CT ST CWS SWS; Qld, Vic., Tas.
Distribution Sydney area:
Select locations: **CC:** Ourimbah, Wilberforce, Cheltenham, Northbridge, Balls Head, Nielsen Park, Parramatta, Liverpool, Menangle, Picton, Mt Cambewarra. **CT:** Rylstone, Blackheath, Mt Wilson, Jenolan Caves, Mt Werong, Fitzroy Falls, Wingello.

Habitat

Habitat: Gullies, hillsides.
Altitude: 0–1000 m **Annual rainfall:** 800–1400 mm
Typical local abundance: Occasional–frequent.
Vegetation: Moist open-forest e.g. with *Eucalyptus saligna;* dry open-forest e.g. with *Angophora bakeri, Corymbia eximia;* heath and scrub.
Substrate: Clay soil and basalt, volcanic rocks, sandy soils on sandstone, medium to high nutrients.
Exposure:

Conservation

Conservation: Widespread and probably adequately conserved.

Billardiera scandens var. *sericata* PITTOSPORACEAE

Appleberry, Snotberry, Apple Dumplings

Life history

Growth form: Climber or scrambler with twining stems to 3 m long; leaves elliptic to narow-elliptic with lower surface hairy.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Cream to greenish-yellow, September–November.
Fruit/seed: Cylindrical berry 10–40 mm long, with seeds encased in mucilaginous pulp (extra data on seed & pulp characteristics in French 1991).
Dispersal, establishment & growth: Diaspore: fruit, adapted for dispersal by ingestion (McIntyre et al. 1995), vertebrate-adapted (Westoby et al. 1990).
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC CC SC; Qld.
Distribution Sydney area:
Select locations: **CC:** Castle Hill, Glenbrook, Peakhurst, Waterfall.

Habitat

Habitat:
Altitude: 0–300 m **Annual rainfall:** 1000–1200 mm
Typical local abundance:
Vegetation: Scrub e.g. with *Leptospermum*.
Substrate:
Exposure:

Conservation

Conservation: Appears to be much rarer and limited in distribution than *B. scandens* var. *scandens*, poorly-conserved.

Bursaria calicola (Cayzer et al. 1999) PITTOSPORACEAE

Native Blackthorn

Life history

Growth form: Spinescent shrub to 3 m high, erect or sprawling.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Cream, November.
Fruit/seed: Flattened purse-like capsule 7–9 mm long, with 1–6 winged seeds 4 x 2 mm, January.
Dispersal, establishment & growth: Diaspore: seed. Germination fairly slow, 4–5 months with about 50–60% success (Cayzer et al. 1999).
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CT.
Distribution Sydney area:
Select locations: CT: Wombeyan Caves, Wolgan Valley.

Habitat

Habitat: Rocky situations.
Altitude: 600–900 m **Annual rainfall:** 600–800 mm
Typical local abundance:
Vegetation: Eucalypt woodland e.g. with *Brachychiton populneus, Acacia chalkeri, Bursaria spinosa.*
Substrate: Clay soils on limestone.
Exposure:

Conservation

Conservation: Local endemic regarded as endangered (Cayzer et al. 1999). Reported from Wombeyan Caves Reserve.

Bursaria longisepala (Cayzer et al. 1999) PITTOSPORACEAE

Native Blackthorn

Life history

Growth form: Shrub, often procumbent and less than 1 m high.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Creamy green sepals, white petals, January.
Fruit/seed: Flattened purse-like capsule 5–6 mm long, with 1–3 seeds, seeds 4 x 2 mm, unevenly winged, May–June.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CT.
Distribution Sydney area: Upper Blue Mountains.
Select locations: CT: Wentworth Falls, Katoomba (Giant Staircase to Scenic Railway).

Habitat

Habitat: South-facing sandstones, cliffs and bluffs.
Altitude: 900–1000 m **Annual rainfall:** 1200–1400 mm
Typical local abundance:
Vegetation: Open-forest; woodland
Substrate: Sandy soils on sandstone.
Exposure:

Conservation

Conservation: Regarded as local endemic restricted to Upper Blue Mountains, conservation status unknown.

Bursaria spinosa subsp. ***lasiophylla*** PITTOSPORACEAE

Native Blackthorn

Life history

Growth form: Multi-stemmed shrub to 5 m high.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: White to cream.
Fruit/seed: Capsule 5–7 mm long.
Dispersal, establishment & growth: Diaspore: seed, wind or gravity-dispersed.
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CT.
Distribution Sydney area: Tablelands.
Select locations: **CT:** Ben Bullen, Lidsdale, Jenolan, Abercrombie Caves, Moss Vale, Tallong.

Habitat

Habitat: Gullies, hillsides.
Altitude: 800–1000 m **Annual rainfall:** 700–1400 mm
Typical local abundance: Occasional.
Vegetation: Eucalypt forest.
Substrate: Sandy soils on alluvium, granite, metamorphic rocks.
Exposure:

Conservation

Conservation: Conservation status unknown.

Bursaria spinosa subsp. *spinosa* (Cayzer et al. 1999) PITTOSPORACEAE

Native Blackthorn

Life history

Growth form: Rigid, much-branched shrub or tree to 5–10 m high, usually with thorny branches.
Vegetative spread: No.
Longevity: Medium-long, 25–60 years.
Primary juvenile period:
Flowers: White or cream, January–August, peak January–March.
Fruit/seed: Purse-like capsule, 5–7 mm long, shedding seeds at maturity, April–May , empty by June.
Dispersal, establishment & growth: Diaspore: seed, wind-dispersed (Westoby et al. 1990). May form dense thickets on ungrazed rural land. Allan Cunningham reported that it increased in abundance on farmed land (Benson & Howell 1990). Coloniser.
Fire response: Adults resprouted from base; susceptibility of seedlings unknown. Secondary juvenile period 16 months.
Interaction with other organisms: Foodplant of moth larvae *Proselena annosana* (Common 1990), *Palaeosia bicosta* and *Ectropis subtinctaria*; *Xanthodule ombrophanes* feeds on lichens and algae often found on the branches; foodplant of butterfly larvae *Paralucia aurifera* attended by small black ants *Iridomyrmex ?nitidiceps*, *Paralucia pyrodiscus pyrodiscus* attended by small black ants *Notoncus* sp., *Paralucia spinifera* associated with small black ants in nests at base of the plant (Common & Waterhouse 1981). Only known larval host plant for Australian Jewel Beetle *Astraeus crassus* which tunnels into dead and dying branches; appears to be under-utilised by the native wood-boring beetle fauna of Australia possibly due to chemical and physical defences of the plant (Turner & Hawkeswood 1996). Cattle may graze young plants but not mature plants. Also grazed by rabbits and may have increased in abundance on Cumberland Plain after destruction of rabbits in 1950s (R. Venables pers. comm.).

Distribution

Status/origin: Native.
Botanical subregions: NC CC SC ST CWS SWS; Qld, Vic., Tas., S.A.
Distribution Sydney area: Widespread, Cumberland Plain forest and coastal estuaries.
Select locations: CC: Putty, Gosford, Mooney Mooney Creek, Pennant Hills, Doonside, Penrith, Campbelltown, Razorback, Meryla.

Habitat

Habitat: Eucalypt woodland.
Altitude: 0–1000 m **Annual rainfall:** 700–1600 mm
Typical local abundance: Frequent.
Vegetation: Dry eucalypt woodland and forest e.g. with *Eucalyptus moluccana*, *E. tereticornis*, *Themeda australis*.
Substrate: Clay soils from Wianamatta Shale and good indicator of shale areas on Cumberland Plain. May be indicator of calcareous soils. Common in volcanic necks — north Blue Mountains (R. Lembit pers. comm.). Often on non-siliceous, medium-nutrient soils. Water table permanently low, moisture supply intermittent, fresh.
Exposure: Light shade to full sun.

Conservation

Conservation: Widespread and probably adequately conserved.

Cheiranthera cyanea var. *cyanea* PITTOSPORACEAE

Finger Flower

Life history

Growth form: Small shrub to 50 cm high, with thick rootstock.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Blue, November–January.
Fruit/seed: Hard capsule 12–18 mm long, with numerous seeds, February.
Dispersal, establishment & growth:
Fire response: Probably resprouts.
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CC SC NT CT ST NWS CWS SWS NWP SWP NFWP; Qld, Vic.
Distribution Sydney area: Mainly Tablelands.
Select locations: CC: Ebeneezer (1937), Kurrajong Heights (1908). **CT:** Rylstone, Ophir, Orange, Bathurst, Marrangaroo Creek, Abercrombie Caves, Peelwood.

Habitat

Habitat: Disturbed sites.
Altitude: 0–1000 m **Annual rainfall:** 600–1000 mm
Typical local abundance: Occasional.
Vegetation: Woodland e.g. with *Eucalyptus mannifera, E. macrorhyncha.*
Substrate: Sandy or stony soils on metamorphic rocks.
Exposure:

Conservation

Conservation: No recent collections from Kurrajong–Richmond area which is the eastern geographical limit (Harden 1992) and possibly extinct there. Conservation status elsewhere unknown.

Citriobatus pauciflorus PITTOSPORACEAE

Life history

Growth form: Rigid, much-branched shrub 1–3 m high with slender spines.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: White, September–October.
Fruit/seed: Indehiscent berry 4–10 mm diam., May–November.
Dispersal, establishment & growth: Fleshy fruit vertebrate-adapted for dispersal (Westoby et al. 1990).
Fire response:
Interaction with other organisms: Food plant of butterfly larvae *Paralucia aurifera* which is also associated with ant's nests at the base of the plant (Common & Waterhouse 1981).

Distribution

Status/origin: Native.
Botanical subregions: NC CC SC NT CT ?ST CWS SWP; Qld.
Distribution Sydney area:
Select locations: CC: Wyong, Eastwood, Peakhurst, Royal NP, Grose Vale, Albion Park, Razorback, Mount Keira, Minnamurra, Cobbity. **CT:** Robertson.

Habitat

Habitat: Forest, creekbanks.
Altitude: 0–700 m **Annual rainfall:** 700–1600 mm
Typical local abundance:
Vegetation: Warm temperate rainforest e.g. with *Doryphora sassafras, Acmena smithii*; dry rainforest e.g. with *Cassine*; gully rainforest e.g. with *Ceratopetalum apetalum, Backhousia myrtifolia, Callicoma serratifolia*; moist open-forest e.g. with *Eucalyptus pilularis, Syncarpia glomulifera.*
Substrate: Clay soils on shales or basalt, well-drained.
Exposure:

Conservation

Conservation: Vulnerable in Western Sydney (James et al. 1999).

Hymenosporum flavum PITTOSPORACEAE

Native Frangipani

Life history

Growth form: Tall shrub or small tree, rarely to 20 m high; leaves sometimes clustered and more or less whorled, 8–16 cm long.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Fragrant, conspicuous, cream to yellow or reddish, partly tubular flowers, October–November.
Fruit/seed: Dry, roundish, thick-valved capsule 20–35 mm long, with numerous flat, winged seeds to 8 mm wide. Fruit mature December–April; 140 000 seeds per kilogram (Floyd 1989).
Dispersal, establishment & growth: Diaspore: seed, wind-dispersed. Seed may be stored for 12–18 months at room temperature or even longer at -2°C; germination is rapid (Floyd 1989).
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC CC NT CT CWS; Qld, N.G.
Distribution Sydney area:
Select locations: CC: Mt Yengo, Calga, Wheeny Creek, Grose Vale.

Habitat

Habitat: In or near rainforest.
Altitude: 0–700 m **Annual rainfall:** 900–1400 mm
Typical local abundance: Frequent.
Vegetation: Rainforest margins; moist open-forest e.g. with *Eucalyptus tereticornis, E. saligna, Syncarpia glomulifera.*
Substrate: Clay soil on shale, basalt, sandy soils with basalt influence, medium to high nutrients.
Exposure:

Conservation

Conservation: Southern geographical limit is Grose Vale. Vulnerable in Western Sydney (James et al. 1999). Sometimes cultivated as an ornamental.

Pittosporum revolutum PITTOSPORACEAE

Life history

Growth form: Shrub to 3 m high; leaves alternate or clustered at the end of branches, the lower surface usually with rusty hairs.
Vegetative spread: May root-sucker vigorously to form clumps 2-3 m across.
Longevity:
Primary juvenile period:
Flowers: Tubular, yellow, September–October. Flowers visited by Honeybee *Apis mellifera* (fed on nectar) and native bee (P. Kubiak pers. comm.).
Fruit/seed: Yellow-orange capsule 12–20 mm long, thick-walled, warty, with numerous red-brown seeds.
Dispersal, establishment & growth: Diaspore: seeds, both vertebrate and ant-adapted for dispersal (Westoby et al. 1990), probably bird-dispersed.
Fire response: Stems killed and regenerate from basal sprouts. Flowering less than 2 years after high intensity fire (1/94) at Lane Cove (P. Kubiak pers. comm.); secondary juvenile period 3 years (Bradley 1972).
Interaction with other organisms: Host plant of Cerambycid beetle *Coptopterus thoracicus* (Hawkeswood 1993). Birds eat green fruit (L. Parkinson pers. comm.).

Distribution

Status/origin: Native.
Botanical subregions: NC CC SC CT ST CWS; Qld, Vic.
Distribution Sydney area: Widespread.
Select locations: **CC:** Glen Davis, Bilpin, Pittwater, Roseville, Eastwood, Hurstville, Cronulla, Douglas Park, Razorback, Cobbity, Shellharbour, Kangaroo Valley, Nowra. **CT:** Mt Victoria.

Habitat

Habitat:
Altitude: 0–1000 m **Annual rainfall:** 800–1400 mm
Typical local abundance: Frequent–occasional.
Vegetation: Rainforest e.g. with *Acmena smithii, Streblus brunonianus*; moist open-forest e.g. with *Syncarpia glomulifera, Angophora costata*; dry open-forest e.g. with *Eucalyptus maculata, E. eugenioides, E. fibrosa, E. punctata, E. crebra.*
Substrate: Clay soils on basalt, Narrabeen Shale, Wianamatta Shale, medium to high nutrients.
Exposure:

Conservation

Conservation: Widespread and probably adequately conserved.

Pittosporum undulatum PITTOSPORACEAE

Native Daphne, Sweet Pittosporum

Life history

Growth form: Tall shrub or tree generally 5–10 m high, conspicuous in August–September when new foliage opens and is brilliant green against the darker green of the old leaves (Fuller & Badans 1980).
Vegetative spread: No.
Longevity: 30–40 years.
Primary juvenile period: 6–8 years.
Flowers: White to cream, August–October peak September. Honeybees probably the main diurnal pollinators (P. Kubiak pers. comm.).
Fruit/seed: Light orange to yellow-brown capsule 10–14 mm long, with numerous sticky, red-brown–orange seeds. Mature summer–autumn (L. Parkinson pers. comm.), January–February (Fuller 1980); 770 fruits and 90 000 seeds per kilogram (Floyd 1989).

Dispersal, establishment & growth: Diaspore: seed, both vertebrate and ant-adapted for dispersal (Westoby et al. 1990). Bird-dispersed (Currawongs, Indian Mynas). Pioneer species. Germination follows disturbance or possibly fire, though may establish in areas unburnt for at least 20 years (at Mosman). Young seedlings conspicuous in deep decomposing leaf litter, or under adults. Germination of fresh seed begins after 48 days with final germination of 23% after 50 days (Floyd 1989).
Fire response: Generally killed though may resprout after low intensity fire. Re-establish from bird-introduced seed. Indicator of areas not frequently burnt.

Interaction with other organisms: Fruit eaten by Grey-headed Flying Fox *Pteropus poliocephalus* (Eby 1995). Fruit reported from pellets of Currawongs (Buchanan 1989a). Foodplant of Red Whiskered Bulbul (Barker & Vestjens 1989,1990), Crimson Rosella and Silvereye (Floyd 1989). Female longicorn beetle *Strongylurus thoracicus* deposits eggs in bark of branch which usually dries out and breaks at the point weakened by the boring of the larvae; pupation usually occurs further into the trunk or lower branches, adults emerging in December (Hawkeswood 1987). Attacked by sap sucking insects, white and pink wax type (Hadlington & Johnston 1977). Host plant of Cerambycid beetle *Coptopterus thoracicus* (Hawkeswood 1993). Leaves, especially new shoots, eaten by caterpillars of *Lamprolina* sp. (J. Howell pers. comm.). Larvae of two small miner flies *Phytobia* species (Agromyzidae) form galls on leaves and stems (Hering 1962). Bark contains a dye (Floyd 1989).

Distribution

Status/origin: Native.
Botanical subregions: NC CC SC NT CT ST NWS CWS; Qld, Vic., Tas., S.A.
Distribution Sydney area: Coast and mountains.
Select locations: **CC:** Howes Valley, Calga, Bilpin, Glen Davis, Barrenjoey, Dee Why, Mosman, Denistone, Campbelltown, Wollongong, Albion Park, Jamberoo, Bomaderry. **CT:** Mt Wilson, Katoomba, Rylstone, Oberon, Mt Werong, Blackheath, Jenolan Caves.

Habitat

Habitat: Moist forest and sheltered gullies.
Altitude: 0–1000 m **Annual rainfall:** 900–1400 mm
Typical local abundance: Frequent–occasional.
Vegetation: Rainforest e.g. with *Doryphora sassafras* and vine scrub; moist open-forest e.g. with *Eucalyptus pilularis–E. paniculata–E. saligna* (North Shore High Forest of Benson & Howell 1990); *E. quadrangulata–Syncarpia glomulifera–E. smithii–E. fastigata* (in Illawarra).
Substrate: On clay or shale-derived soil, granite, alluvium, basalt; young plants also found on dry sandstone particularly at infrequently burnt urban bushland reserves.
Exposure: Sheltered, mid-shade to light shade.

Conservation

Conservation: Widespread species occurring naturally in Sydney area in moist forest but spreading in urban bushland in absence of fires and increase in bird-dispersers; often dominating unburnt urban bushland edges. Becoming a weed in natural situations, outside its natural range e.g. at Wilsons promontory (Vic.) as a result of dispersal by exotic birds.

Rhytidosporum procumbens PITTOSPORACEAE

Life history

Growth form: Dwarf shrub sometimes almost prostrate, with slender rootstock.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: White, often with mauve on outside, September–November.
Fruit/seed: Thin leathery capsule 5–8 mm wide, September–January.
Dispersal, establishment & growth:
Fire response: One plant resprouted and flowered in less than 10 months after high intensity fire (1/94) at Narrabeen, but most plants appeared to be seedlings at Lane Cove (P. Kubiak pers. comm.).
Interaction with other organisms: Butterflies probably feed on nectar (P. Kubiak pers. comm.).

Distribution

Status/origin: Native.
Botanical subregions: NC CC SC NT CT ST NWS CWS SWP; Qld, Vic., Tas., S.A.
Distribution Sydney area: Widespread.
Select locations: **CC:** Hornsby, Rookwood, Bargo, Appin, Nowra. **CT:** Capertee, Clarence, Katoomba, Wentworth Falls, Bathurst, Jenolan SF, Hill Top, Robertson, Wingello.

Habitat

Habitat:
Altitude: 0–1100 m **Annual rainfall:** 700–1600 mm
Typical local abundance: Frequent–occasional.
Vegetation: Open-forest e.g. with *Eucalyptus sieberi, E. radiata, E. pauciflora* or woodland e.g. with *Eucalyptus crebra, E. tenella, E. mannifera*; heath e.g. with *Allocasuarina nana*; scrub e.g. with *Melaleuca nodosa, Kunzea ambigua.*
Substrate: Sandy soils on sandstone, granite, metamorphics, sandy clay soils on shale, often with ironstone gravels, low nutrients.
Exposure:

Conservation

Conservation: Conservation status unknown.

Rhytidosporum prostratum PITTOSPORACEAE

Life history

Growth form: Dwarf shrub with swollen rootstock and prostrate or trailing stems.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: White with pale mauve outside, December–January.
Fruit/seed: Capsule 3–4 mm long,
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: SC CT ST.
Distribution Sydney area:
Select locations: **CT:** Barren Grounds, Carrington Falls.

Habitat

Habitat:
Altitude: 600–1000 m **Annual rainfall:** 1400–1600 mm
Typical local abundance:
Vegetation: Woodland and wet heath
Substrate: Peaty soil on sandstone, low nutrients.
Exposure:

Conservation

Conservation: Carrington Falls is northern geographical limit. Reported from Barren Grounds Nature Reserve.

Plantago coronopus subsp. *commutata* * PLANTAGINACEAE

Buck's-horn Plantain

Life history

Growth form: Perennial or annual herb, with a persistent taproot and basal leaves; stout flower scapes to 45 cm high.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Small, compressed, in spikes, September–December.
Fruit/seed: Egg-shaped capsule 2–3 mm long, usually with 5 seeds, 0.4 mm diam.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to S & E Mediterranean region.
Botanical subregions: CC SC ST CWS SWS SWP; Vic, Tas., S.A., W.A.
Distribution Sydney area: Inner Sydney.
Select locations: **CC:** Carlton (1897), Kogarah (1899), Cooks River (1909), Rose Bay (1899).

Habitat

Habitat: Disturbed sites, maritime environments.
Altitude: 0–50 m **Annual rainfall:** 1000–1200 mm
Typical local abundance:
Vegetation:
Substrate: Reported from detritus mounds in saltmarsh on Cooks River (1909). Recorded on saline sites in western NSW (Semple 1993).
Exposure: Full sun.

Conservation

Conservation: Minor coastal weed reported from Sydney area in 1909.

Plantago coronopus subsp. *coronopus* * PLANTAGINACEAE

Buck's-horn Plantain

Life history

Growth form: Perennial or annual herb, with a persistent taproot and basal leaves; slender flower scapes to 45 cm high.
Vegetative spread:
Longevity: Less than ?5 years.
Primary juvenile period:
Flowers: Small, compressed, in spikes, September–December.
Fruit/seed: Egg-shaped capsule 2–3 mm long, usually with 5 seeds, 0.4 mm diam.
Dispersal, establishment & growth: Dispersed in mud on cars (Wace 1977).
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to Europe and W Asia.
Botanical subregions: CC SC NT CT ST; Qld, Vic., Tas., W.A.
Distribution Sydney area: Mainly coast.
Select locations: **CC:** Narrabeen, Sailors Bay, Putney, Coogee, Queenscliff Lagoon, Bronte Beach, La Perouse, Kogarah. **CT:** Orange (1978).

Habitat

Habitat: Coastal headlands, seacliffs, dredge spoil.
Altitude: 0–1000 m **Annual rainfall:** 800–1400 mm
Typical local abundance: Frequent–occasional.
Vegetation: Grassland on headlands e.g. with *Isolepis nodosa, Samolus repens, Stenotaphrum secundatum.*
Substrate: Sandy soil on sandstone, low nutrients.
Exposure:

Conservation

Conservation: Minor coastal weed. Only one record for Central Tablelands — Orange, in lawn (1978).

Plantago debilis PLANTAGINACEAE

Life history

Growth form: Perennial or annual hairy herb with persistent taproot.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Small, tubular, green or white or purplish, at any time of year, peak March.
Fruit/seed: Capsule 1.5–3 mm long, with up to 5 seeds, 1 mm long, mature March–May.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC CC SC NT CT ST NWS CWS SWS NWP SWP NFWP; Qld, Vic., Tas., N.T., S.A., W.A.
Distribution Sydney area: Widespread.
Select locations: CC: Avoca, Patonga Creek, Hornsby, Galston, Bayview, Homebush, Duck River, Kogarah, Ingleburn, Bundeena, Campbelltown, Mt Kembla, Albion Park. **CT:** Winburndale, Mt Wilson, Wentworth Falls, Kanangra, Abercrombie Caves, Wombeyan Caves.

Habitat

Habitat: Forest.
Altitude: 0–1100 m **Annual rainfall:** 700–1400 mm
Typical local abundance: Frequent–occasional.
Vegetation: Rainforest e.g. with *Ceratopetalum apetalum, Doryphora sassafras, Acacia melanoxylon*; moist open-forest e.g. with *Eucalyptus fastigata, D. radiata, E. deanei, Syncarpia glomulifera*; open-forest e.g. with *Eucalyptus amplifolia, E. eugenioides, E. melliodora, Angophora floribunda*; coastal scrub e.g. with *Leptospermum laevigatum, Westringia fruticosa.*
Substrate: Clay soils on basalt, shale, alluvium, high–medium nutrients.
Exposure:

Conservation

Conservation: Vulnerable in Western Sydney (James et al. 1999). Conservation status elsewhere unknown.

Plantago drummondii PLANTAGINACEAE

Life history

Growth form: Annual or short-lived, hairy, perennial herb with basal leaves and a persistent taproot.
Vegetative spread:
Longevity: Less than ?5 years.
Primary juvenile period:
Flowers: In a spike, mainly May–October. Generally regarded as wind-pollinated, though insects are also visitors and may be responsible for some pollination (B. Briggs pers. comm.).
Fruit/seed: Capsule 3–5 mm long, with up to 5 seeds, 2–2.7 mm long.
Dispersal, establishment & growth: *Plantago* species, especially *P. drummondii* have a layer of mucilage around the seeds (dry when shed), this may assist dispersal or may facilitate germination/establishment (B. Briggs pers. comm.).
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CT NWP SWP NFWP SFWP; Qld, Vic., S.A., N.T., W.A.
Distribution Sydney area: Orange.
Select locations: **CT:** Nashdale (1980), only record.

Habitat

Habitat: Temporarily moist sites.
Altitude: 600 m **Annual rainfall:** 800 mm
Typical local abundance: Occasional.
Vegetation: Grassland; shrubland
Substrate: Basalt soil.
Exposure:

Conservation

Conservation: Mainly found in Western Plains. One record for Sydney area at Nashdale near Orange.

Plantago gaudichaudii PLANTAGINACEAE

Life history

Growth form: Perennial herb with a long thick fleshy taproot; secondary roots thick and sometimes giving rise to new plants (Briggs, Carolin & Pulley 1977), leaves 3-veined with brownish hairs in the leaf axil; flower scapes about as long as the leaves.
Vegetative spread: No (McIntyre et al. 1995), but see comment above.
Longevity:
Primary juvenile period:
Flowers: Small, tubular, green, white, or purplish, mainly September–April.
Fruit/seed: Egg-shaped capsule 2.5–4 mm long, with up to 5 seeds, 2.2 mm long, mature October–April.
Dispersal, establishment & growth: No particular morphology for dispersal (McIntyre et al. 1995).
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC CC SC NT CT ST CWS SWS SWP; Qld, Vic., Tas., S.A.
Distribution Sydney area: Mainly western Sydney.
Select locations: **CC:** Marayong, Doonside, Penrith, Bringelly, Liverpool, Campbelltown, Ingleburn. **CT:** BenBullen, Moss Vale, Wombeyan Caves.

Habitat

Habitat: Cemeteries, woodland remnants, along creeks.
Altitude: 0–1000 m **Annual rainfall:** 700–900 mm
Typical local abundance: Frequent.
Vegetation: Grassland and woodland e.g. with *Eucalyptus moluccana, E. tereticornis, Melaleuca decora, Themeda australis*; riparian woodland e.g. with *Casuarina glauca.*
Substrate: Clay soil on Wianamatta Shale, alluvium, medium nutrients.
Exposure:

Conservation

Conservation: Vulnerable in Western Sydney (James et al. 1999). Conservation status elsewhere unknown.

Plantago hispida PLANTAGINACEAE

Life history

Growth form: Perennial herb with a persistent, often stout taproot.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Small, tubular, green, white, or purplish, mainly October–March.
Fruit/seed: Capsule 2.5–3.5 mm long, with up to 5 seeds, 1–1.5 mm long, mature February–April.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC CC SC NT CT ST NWS CWS NWP SWP NFWP; Qld, Vic., Tas., S.A., W.A.
Distribution Sydney area: Coastal sites and Tablelands.
Select locations: **CC:** Narrabeen, Long Reef, Kurnell, Jibbon Head, Five Islands, Shellharbour, Kiama. **CT:** Winburndale NR, Boyd Plateau, Abercrombie Caves, Mullions Range, Mt Bindo, Wingello.

Habitat

Habitat: Exposed headlands; shallow soil in crevices of rock exposures (B. Briggs pers. comm.).
Altitude: 0–1200 m **Annual rainfall:** 900–1600 mm
Typical local abundance: Frequent–occasional.
Vegetation: Coastal grassland e.g. with *Lomandra longifolia, Westringia fruticosa*; Montane Forest e.g. with *Eucalyptus pauciflora, E. dalrympleana.*
Substrate: Shallow soils and rock crevices often exposed to seaspray drift, on basalt, shale, sandstone on coast. On granite, metamorphics, basalt on Tablelands, medium–high nutrients.
Exposure:

Conservation

Conservation: Conservation status unknown.

Plantago lanceolata * PLANTAGINACEAE

Lamb's Tongues, Plantain, Ribgrass

Life history

Growth form: Annual or biennial hairy herb, with a persistent taproot.
Vegetative spread: No (McIntyre et al. 1995).
Longevity: 1–2 years.
Primary juvenile period: 1 year.
Flowers: Small, in spikes, mainly September–April. Honeybees and native bees may be pollinators (P. Kubiak pers. comm.).
Fruit/seed: Capsule 3–4 mm long, with 1–2 seeds, 2.5–3 mm long.
Dispersal, establishment & growth: No particular morphology for dispersal (McIntyre et al. 1995), dispersed in mud on cars (Wace 1977).
Fire response: Resprouted after high intensity fire (1/94) at Lane Cove; secondary juvenile period 10 months (P. Kubiak pers. comm.).
Interaction with other organisms: Seed eaten by Galah *Cacatua roseicapilla*, roots eaten by Sulphur-crested Cockatoo *Cacatua galerita* (Lepschi 1993). Foodplant of Stubble Quail *Coturnix pectoralis* (Barker & Vestjens 1989, 1990). Host to larvae of moths *Scopula rubraria* and *Xanthorhoe vicissata* (Common 1990) and butterfly *Junonia villida calybe* (Common & Waterhouse 1981). Known to cause seasonal allergic rhinitis in humans (Bass 1987).

Distribution

Status/origin: Exotic, native to Europe, N and C Asia.
Botanical subregions: NC CC SC NT CT ST NWS CWS SWS SWP; LHI, Qld, Vic., Tas., S.A., W.A.
Distribution Sydney area: Widespread.
Select locations: **CC:** Wisemans Ferry, Hornsby, Pennant Hills, Lane Cove, Parramatta, Campbelltown, Ingleburn, Illawarra Lake, Berry. **CT:** Burradoo, Bowenfels, Bathurst, Jenolan Caves, Fitzroy Falls.

Habitat

Habitat: Disturbed sites, pastures, gardens, roadsides, lawns.
Altitude: 0–1000 m **Annual rainfall:** 600–1400 mm
Typical local abundance: Frequent.
Vegetation: Grassland e.g. with *Themeda australis*; wetland margins, pastures, lawn.
Substrate: Sandy to clay soils on sandstones, shale, basalt, alluvium, low–high nutrients. Recorded on saline sites in western NSW (Semple 1993).
Exposure: Full sun to light shade.

Conservation

Conservation: Common weed of frequently disturbed sites, unlikely to invade undisturbed bush.

Plantago major * PLANTAGINACEAE

Large Plantain

Life history

Growth form: Short-lived perennial herb, with a mostly adventitious root system; leaves basal, flower scapes to 40 cm high.
Vegetative spread:
Longevity: Less than ?5 years.
Primary juvenile period:
Flowers: Small, October–March.
Fruit/seed: Roundish capsule 5–6 mm long, with up to 16 seeds. Seeds 2 mm long, weight 0.16 mg, germination 99% within 30 days (Shipley & Parent 1991), mature November–April.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms: American Indians used the whole plant for tea, and for poultices (Murphy 1990).

Distribution

Status/origin: Exotic, native to Europe, N & C Asia. Reported by Robert Brown to be introduced to Sydney by 1804 (Maiden 1909).
Botanical subregions: NC CC SC NT CT ST CWS SWS; LHI, Qld, Vic., Tas., S.A., W.A.
Distribution Sydney area: Coastal and western Sydney.
Select locations: CC: N. Richmond, Hornsby, Royal Botanic Gardens (1892, 1901), Woolloomooloo Bay, Bronte Beach, Arncliffe, Macquarie Fields, Picton, Bulli Pass, Wollongong, Albion Park. **CT:** Lithgow.

Habitat

Habitat: Creekbanks, seepage lines, headlands.
Altitude: 0–200 m **Annual rainfall:** 700–1400 mm
Typical local abundance: Frequent to occasional.
Vegetation: Rainforest margins, coastal seepage areas e.g. with *Baumea juncea, Triglochin striata, Lobelia alata, Empodisma minus.*
Substrate: Moist sandy or gravelly alluvial soils, seepage areas on sandstone cliffs.
Exposure: Mid-shade.

Conservation

Conservation: Minor weed of disturbed sites.

Plantago myosuros subsp. *myosuros* * PLANTAGINACEAE

Life history

Growth form: Annual herb, with a persistent taproot and basal leaves; flower scapes 5–20 cm high.
Vegetative spread: No.
Longevity: Less than 1 year.
Primary juvenile period: Less than 1 year.
Flowers: Small, in spikes, October–December.
Fruit/seed: Roundish capsule 2.5 mm long, with 3 seeds, 1–2 mm long, mature October–November.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to S America (Ecuador to Argentina).
Botanical subregions: NC CC SC; Qld.
Distribution Sydney area: Western Sydney.
Select locations: CC: Port Jackson (1884), Marayong, Doonside, Liverpool, Casula, Glenfield, Camden.

Habitat

Habitat: Roadside and woodland remnants.
Altitude: 0–200 m **Annual rainfall:** 700–1000 mm
Typical local abundance: Frequent–occasional.
Vegetation: Grassland and grass verges; woodland e.g. with *Eucalyptus moluccana, E. tereticornis;* scrub e.g. with *Melaleuca decora, M. nodosa, M. erubescens, Eucalyptus parramattensis.*
Substrate: Clay soil on Wianamatta Shale, medium nutrients.
Exposure: Full sun.

Conservation

Conservation: Minor weed of disturbed sites.

Plantago turrifera PLANTAGINACEAE

Life history

Growth form: Annual herb, with a persistent taproot; leaves basal, flower scapes to 20 cm long.
Vegetative spread: No.
Longevity: Less than 1 year.
Primary juvenile period: Less than 1 year.
Flowers: Small, mainly August–February.
Fruit/seed: Roundish capsule 3–4 mm long, with up to 5 seeds, 1.2–1.8 mm long.
Dispersal, establishment & growth:
Fire response: Probably killed.
Interaction with other organisms:

Distribution

Status/origin: Native to Australia, but naturalised in the Blue Mountains and Sydney area.
Botanical subregions: *CC *CT CWS NWP SWP NFWP SFWP; Qld, Vic., S.A., W.A.
Distribution Sydney area:
Select locations: **CC:** Flemington Saleyards (1969). **CT:** Blue Mountains (1887), only records.

Habitat

Habitat: Moist sites.
Altitude: **Annual rainfall:** 1000 mm
Typical local abundance:
Vegetation: Grassland, forest, woodland.
Substrate: Temporarily moist open sites.
Exposure:

Conservation

Conservation: Widespread on drier inland areas, and probably introduced to Sydney area with stock, though probably not persisting in the Sydney area now.

Plantago varia PLANTAGINACEAE

Variable Plantain

Life history

Growth form: Perennial hairy herb, with a persistent, often stout taproot; leaves basal, flower scapes 8–20 cm long.
Vegetative spread: No (McIntyre et al. 1995).
Longevity:
Primary juvenile period:
Flowers: Small, mainly August–March.
Fruit/seed: Roundish capsule 3–4 mm long, with up to 5 seeds, 1.5–1.8 mm long.
Dispersal, establishment & growth: No particular morphology for dispersal (McIntyre et al. 1995).
Fire response:
Interaction with other organisms: Foodplant of Stubble Quail *Coturnix pectoralis* (Barker & Vestjens 1989, 1990).

Distribution

Status/origin: Native.
Botanical subregions: NC CC SC NT CT ST CWS SWS SWP; Qld, Vic., Tas., S.A.
Distribution Sydney area: Western Sydney and Tablelands.
Select locations: **CC:** Richmond, Windsor, Camden, Yerranderie, Appin. **CT:** Mt Coricudgy, Mt Canobolas, Mullions Range, Hartley, Mittagong, Wombeyan Caves.

Habitat

Habitat: Grassland, forest.
Altitude: 0–1300 m **Annual rainfall:** 700–1000 mm
Typical local abundance: Frequent.
Vegetation: Open-forest e.g. with *Eucalyptus fastigata, E. piperita, E. radiata, E. blaxlandii*; woodland e.g with *Eucalyptus macrorhyncha, E. bridgesiana, E. viminalis.*
Substrate: Clay soils on shale , basalt, limestone, alluvium, medium to high nutrients.
Exposure: Full sun to light shade.

Conservation

Conservation: Vulnerable in Western Sydney (James et al. 1999), but widespread and common on Tablelands and adequately conserved there (B. Briggs pers. comm.).

Limonium australe PLUMBAGINACEAE

Native Sea Lavender

Life history

Growth form: Perennial herb to 40 cm high, with basal leaves and flowering stems.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Yellow, tubular, November–February.
Fruit/seed: Small capsule, with persistent calyx.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CC SC; Qld, Vic., Tas.
Distribution Sydney area: Minnamurra.
Select locations: **CC:** Minnamurra River, Blow-hole Kiama

Habitat

Habitat: Saltmarshes.
Altitude: 0–20 m **Annual rainfall:** 1200–1400 mm
Typical local abundance: Occasional.
Vegetation: Saltmarsh e.g. with *Sarcocornia quinquenervia, Sporobolus virginicus.*
Substrate: Estuarine alluvium with periodic tidal inundation.
Exposure: Full sun.

Conservation

Conservation: Rare, conservation status unknown.

Collomia grandiflora * POLEMONIACEAE

Life history

Growth form: Erect annual herb to 1 m high.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Pink
Fruit/seed: Capsule 5 mm long, with 2 seeds.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to N America.
Botanical subregions: NT CT ST CWS SWS; Tas.
Distribution Sydney area:
Select locations:

Habitat

Habitat:
Altitude: **Annual rainfall:**
Typical local abundance:
Vegetation:
Substrate:
Exposure:

Conservation

Conservation: Weed of disturbed areas. Widespread but not common.

Navarretia squarrosa * POLEMONIACEAE

Californian Stinkweed

Life history

Growth form: Erect annual hairy herb to 60 cm high, with a strong odour.
Vegetative spread:
Longevity: 1 year.
Primary juvenile period: Less than 1 year.
Flowers: Pale lilac to blue, summer.
Fruit/seed: Capsule with numerous seeds.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to N America.
Botanical subregions: NT CT ST CWS SWS; Tas.
Distribution Sydney area:
Select locations: **CT:** Kelso, Orange.

Habitat

Habitat: Garbage dump.
Altitude: 700–800 m **Annual rainfall:** 600–900 mm
Typical local abundance: Occasional.
Vegetation:
Substrate:
Exposure:

Conservation

Conservation: Occasionally naturalised on wasteland or cultivated land.

Comesperma defoliatum POLYGALACEAE

Life history

Growth form: Slender shrub to 60 cm high, with numerous leafless stems arising from a woody base.
Vegetative spread:
Longevity: 25–60 years (D. Keith pers. comm.).
Primary juvenile period: Primary juvenile period more than 1 year (D. Keith pers. comm.).
Flowers: Blue or purplish-blue, November–February.
Fruit/seed: Compressed wedge-shaped capsule 7–11 mm long; seeds with tufts of hairs, January–February.
Dispersal, establishment & growth: Recruitment mainly after fire (D. Keith pers. comm.).
Fire response: Resprouts, secondary juvenile period 1 year (D. Keith pers. comm.).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC CC SC NT CT; Qld, Vic., Tas.
Distribution Sydney area:
Select locations: **CC:** Berowra Creek, Narrabeen, Cabramatta, Maddens Plains. **CT:** Rylstone, Blackheath, Wentworth Falls, Leura, Hill Top.

Habitat

Habitat: Wet sandy heath, swamps, watercourses.
Altitude: 0–1000 m **Annual rainfall:** 900–1400 mm
Typical local abundance: Rare.
Vegetation: Wet heath, swamp margins.
Substrate: Sandy soil over sandstone, low nutrients.
Exposure:

Conservation

Conservation: Relatively uncommon, conservation status unknown.

Comesperma ericinum POLYGALACEAE

Life history

Growth form: Shrub 1–1.5 m high, with reddish stems. This taxon is variable in leaf shape and is sometimes divided into several species or informal variants.
Vegetative spread:
Longevity:
Primary juvenile period: Less than 2 years (P. Kubiak pers. comm.).
Flowers: Purple, lilac-pink or white, at any time of year but mainly September–December. Probably pollinated by Honeybee and native bees (P. Kubiak pers. comm.).
Fruit/seed: Compressed wedge-shaped capsule 7–8 mm long; seeds with tufts of hairs, November–February.
Dispersal, establishment & growth:
Fire response: Probably killed after high intensity fire (1/94) at Lane Cove (P. Kubiak pers. comm.).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC CC SC NT CT ST CWS SWS; Qld, Vic., Tas., S.A.
Distribution Sydney area:
Select locations: **CC:** Morisset, Putty, Calga, Hornsby, Cheltenham, Frenchs Forest, Kogarah, Long Bay, Loftus, Bargo, Glenbrook, Springwood. **CT:** Rylstone, Capertee, Orange, Lithgow, Clarence, Blackheath, Trunkey, Hill Top, Robertson.

Habitat

Habitat: Ridges, plateaus.
Altitude: 0–1100 m **Annual rainfall:** 900–1600 mm
Typical local abundance: Occasional.
Vegetation: Heath and scrub e.g. with *Angophora hispida, Allocasuarina littoralis*; woodland e.g. with *Corymbia eximia, Angophora costata, Eucalyptus radiata, E. mannifera.*
Substrate: Sandy soils or sandy soils with clay influence, low nutrients.
Exposure: Light shade to full sun.

Conservation

Conservation: Probably adequately conserved.

Comesperma retusum POLYGALACEAE

Life history

Growth form: Shrub to 1.5 m high, with pinkish, warty stems.
Vegetative spread:
Longevity: 25–60 years (D. Keith pers. comm.).
Primary juvenile period: Primary juvenile period more than 6 years (D. Keith pers. comm.).
Flowers: Purple or lilac-pink, October–December.
Fruit/seed: Compressed wedge-shaped capsule 9–12 mm long; seeds with tufts of hairs.
Dispersal, establishment & growth: Recruitment mainly after fire (D. Keith pers. comm.).
Fire response: Resprouts, secondary juvenile period 5 years (D. Keith pers. comm.).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC CC NT CT ST; Qld, Vic., Tas.
Distribution Sydney area: Mainly Tablelands.
Select locations: **CC:** Centennial Park. **CT:** Mt Victoria, Wentworth Falls, Boyd Plateau swamps (Kodela et al. 1996), Mt Werong, Wingecarribee Swamp, Wingello.

Habitat

Habitat: Permanently wet places more than 600 m altitude, but occasionally coastal swamps.
Altitude: 0–1000 m **Annual rainfall:** 1000–1600 mm
Typical local abundance: Frequent.
Vegetation: Montane peatland, sedgeland e.g. with *Leptospermum obovatum, Lepyrodia anarthria, Carex.*
Substrate: Peat, low nutrients, permanently moist.
Exposure:

Conservation

Conservation: Vulnerable. Extinct in Central Coast — last recorded 1895. Last recorded in Blue Mountains in 1965. Recorded from Wingecarribee Swamp in 1992.

Comesperma sphaerocarpum POLYGALACEAE

Life history

Growth form: Straggling shrub to 20 cm high, with more or less leafless stems and woody taproot.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Bright purplish-blue, October–April.
Fruit/seed: Compressed wedge-shaped capsule 4 mm long; seeds with tufts of hairs.
Dispersal, establishment & growth: Food body ant-adapted for dispersal (Westoby et al. 1990).
Fire response: Resprouts from base after high intensity fire (1/1994 at West Head and Mona Vale) (L.McD.); secondary juvenile period less than 5 months after high intensity fire (1/94) at Lane Cove (P. Kubiak pers. comm.).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC CC SC NT CT ST NWS.
Distribution Sydney area: Widespread.
Select locations: **CC:** Boorai Ridge, Wisemans Ferry, Vineyard, Londonderry, Hornsby, Coasters Retreat, Casula, Agnes Banks, Douglas Park, Avon Dam. **CT:** Mt Banks, Katoomba, Wingello.

Habitat

Habitat:
Altitude: 0–1000 m **Annual rainfall:** 700–1400 mm
Typical local abundance: Occasional.
Vegetation: Woodland e.g. with *Eucalyptus sclerophylla, Angophora bakeri, Eucalyptus parramattensis, E. sideroxylon, E. punctata, E. fibrosa*; heath and mallee e.g. with *Eucalyptus stricta.*
Substrate: Sandy soil on sandstone, Tertiary alluvial sediments, alluvial sand, low nutrients.
Exposure: Light shade to full sun.

Conservation

Conservation: Vulnerable in Western Sydney (James et al. 1999). Conservation status elsewhere unknown.

Comesperma volubile POLYGALACEAE

Life history

Growth form: Climber with stems 1–2 m long, more or less leafless or sparsely leaved.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Purplish-blue, blue-mauve, or white, August–October. Probably pollinated by honeybees (P. Kubiak pers. comm.).
Fruit/seed: Compressed wedge-shaped capsule 10–15 mm long; seeds with tufts of hairs.
Dispersal, establishment & growth: Wind-dispersed (Westoby et al. 1990).
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC CC SC NT CT ST; Qld, Vic., Tas.
Distribution Sydney area:
Select locations: **CC:** Mt Warrawolong, Patonga Creek, Cowan, Hornsby, Belrose, Kentlyn, Narrabeen, Frenchs Forest, Oatley, Springwood. **CT:** Glen Davis, Mt Wilson, Katoomba, Jenolan Caves, Yerranderie, Mt Colong, Hill Top, Barbers Creek.

Habitat

Habitat:
Altitude: 0–1000 m **Annual rainfall:** 800–1400 mm
Typical local abundance: Occasional.
Vegetation: Moist open-forest; open-forest e.g. with *Eucalyptus globoidea, Corymbia gummifera, Eucalyptus piperita*; heath e.g. with *Banksia ericifolia.*
Substrate: Sandy soil on sandstone, low nutrients.
Exposure: Light shade.

Conservation

Conservation: Conservation status unknown.

Muraltia heisteria * POLYGALACEAE

Life history

Growth form: Stiff shrub to 1 m high, foliage with a tufted appearance, leaves clustered along stems.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Purple to pinkish-mauve or white, August–October.
Fruit/seed: Compressed capsule 5 mm long, with horn-like appendages.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to Africa. Introduced as ornamental.
Botanical subregions: CC; Vic., S.A.
Distribution Sydney area: Coastal eastern suburbs of Sydney.
Select locations: **CC:** Bronte Beach (1886, 1976), Bondi (1898).

Habitat

Habitat:
Altitude: 0–50 m **Annual rainfall:** 1200–1400 mm
Typical local abundance: Rare.
Vegetation: Coastal scrub e.g. with *Leptospermum laevigata, Acacia sophorae, Lomandra longifolia.*
Substrate: Sandy soil.
Exposure:

Conservation

Conservation: Cultivated and occasionally naturalised in coastal eastern suburbs of Sydney. Appears to be locally naturalised by 1900 but has not spread since.

Polygala japonica POLYGALACEAE

Life history

Growth form: Perennial herb 10–20 cm high.
Vegetative spread: No (McIntyre et al. 1995).
Longevity:
Primary juvenile period:
Flowers: Mauve–purple, mainly October–March.
Fruit/seed: Capsule 4 mm long.
Dispersal, establishment & growth: No particular morphology for dispersal (McIntyre et al. 1995).
Fire response: Possibly resprouts.
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC CC SC NT CT ST NWS CWS; Qld, Vic.
Distribution Sydney area: Mainly western Sydney.
Select locations: **CC:** Pitt Town, Bass Hill, Narellan, Camden, The Oaks. **CT:** Lithgow.

Habitat

Habitat: Grassland and grassy understorey of forest and woodland.
Altitude: 0–1000 m **Annual rainfall:** 700–1100 mm
Typical local abundance: Rare–occasional.
Vegetation: Grassy understorey e.g. with *Themeda australis, Bothriochloa, Glycine, Desmodium;* woodland e.g. with *Eucalyptus tereticornis, E. crebra.*
Substrate: Clay soils on shale, medium nutrients.
Exposure:

Conservation

Conservation: Vulnerable in Western Sydney (James et al. 1999). Conservation status elsewhere unknown.

Polygala myrtifolia * POLYGALACEAE

Life history

Growth form: Erect shrub 1–2.5 m high, with dense foliage.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Purple to pale lilac, throughout the year, peak September–November.
Fruit/seed: Roundish capsule 8–10 mm diam.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to Africa. Introduced as ornamental.
Botanical subregions: NC CC; Vic., S.A., W.A.
Distribution Sydney area: Coastal.
Select locations: CC: Galston, Bayview, Dalrymple Hay NR, Beecroft, Mosman, Rose Bay, Kogarah, Oatley, Casula, Wollongong.

Habitat

Habitat: Hillsides, harbour foreshores.
Altitude: 0–50 m **Annual rainfall:** 800–1400 mm
Typical local abundance: Frequent–occasional.
Vegetation: Edges of woodland e.g. with *Angophora costata*; open-forest e.g. with *Eucalyptus saligna, E. pilularis*; also estuarine sites.
Substrate: Clay soils on shale, alluvium, medium nutrients.
Exposure:

Conservation

Conservation: Often cultivated as an ornamental. Minor weed on margins of urban bushland.

Polygala paniculata * POLYGALACEAE

Life history

Growth form: Erect, much-branched perennial herb 10–50 cm high, woody at base.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: White or rose-pink to purple, July.
Fruit/seed: Capsule 2 mm long.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to tropical America.
Botanical subregions: NC CC; Qld.
Distribution Sydney area: Warragamba Dam area.
Select locations: CC: Warragamba (1989).

Habitat

Habitat: Creek.
Altitude: 0–100 m **Annual rainfall:** 1000 mm
Typical local abundance: Frequent.
Vegetation: Riparian scrub with *Leptospermum polygalifolium.*
Substrate: Sandy alluvium, low nutrients.
Exposure:

Conservation

Conservation: Locally naturalised at Warragamba, capacity to spread unknown.

Polygala virgata * POLYGALACEAE

Life history

Growth form: Slender shrub to 3 m high.
Vegetative spread: No.
Longevity:
Primary juvenile period:
Flowers: Purple–Lilac, March–November, peak October.
Fruit/seed: Capsule 10 mm long, mature July.
Dispersal, establishment & growth: Diaspore: seed. Prolific seeder and germinator (Anon 1991).
Fire response: Killed by high intensity fire (1/94) at Lane Cove; secondary juvenile period less than 3 years (P. Kubiak pers. comm.).
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to Africa.
Botanical subregions: NC CC.
Distribution Sydney area: Coastal, Myall Lakes to Dapto.
Select locations: CC: Morriset, Pymble (1904), Middle Harbour (1888), Kurnell (1908, 1969, 1984), Heathcote (1976), Camden (1945), Dapto.

Habitat

Habitat: Disturbed areas.
Altitude: 0–200 m **Annual rainfall:** above 1200 mm
Typical local abundance: Frequent.
Vegetation: Sedge swamp, woodland e.g with *Imperata cylindrica, Baumea, Juncus;* roadside e.g. with *Chloris gayana, Bothriochloa macra, Medicago sativa.*
Substrate: Dune sand, sandstone, Wianamatta Shale. Soil low to medium nutrients. Water table mostly low, moisture supply intermittent, fresh.
Exposure: Light shade to full sun.

Conservation

Conservation: Potentially weedy species common in disturbed areas along railway line near Heathcote and probably spreading. Southern recorded geographical limit is Dapto (1996).

Acetosa sagittata * POLYGONACEAE

Rambling Dock, Turkey Rhubarb

Life history

Growth form: Perennial climber, with stems usually more than 100 cm long, often with purplish ribs, and large potato-like tubers and rhizomes.
Vegetative spread: Spread by rhizomes up to 5 metres.
Longevity: Indefinite.
Primary juvenile period:
Flowers: Small cream, unisexual, clustered in panicle-like inflorescences, December.
Fruit/seed: Triangular nut, with papery valves straw-coloured at maturity, sometimes tinged with pink or purple, January–October.
Dispersal, establishment & growth: Diaspore: nut, dispersed by wind, water and gravity; tubers spread by soil movement or dumping of garden refuse. Seed has some dormancy, with germination for at least 2 years after removal of parent plant (M. Clarke pers. comm.).
Fire response: Resprouts from tubers. Secondary juvenile period less than 8 months after high intensity fire (1/94) at Lane Cove (P. Kubiak pers. comm.). Germinates and colonises after fire (M. Clarke pers. comm.).
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to S Africa. Introduced as ornamental.
Botanical subregions: NC CC SC NT; Qld, Vic., Tas., W.A.
Distribution Sydney area: Coastal.
Select locations: CC: Terrigal, Chatswood, Balgowlah, Rockdale (1903), La Perouse, Liverpool, Bulli (1899), Austinmer, Otford.

Habitat

Habitat: Damp, disturbed areas, roadsides, riverbanks.
Altitude: 0–200 m **Annual rainfall:** 900–1600 mm
Typical local abundance: Frequent.
Vegetation: Disturbed sites.
Substrate: Clay soils on shale, sandy soil on sandstone and sand, medium to low nutrients, poorly drained sites.
Exposure: Light shade to full sun.

Conservation

Conservation: A widespread weed of urban bushland that is difficult to eradicate because of its persistant root system and abundant seeding.

Acetosa vesicaria * POLYGONACEAE

Bladder Dock, Rosy Dock

Life history

Growth form: Erect tufted annual herb with stout, succulent stems 20–100 cm high.
Vegetative spread:
Longevity: Less than 1 year.
Primary juvenile period: Less than 1 year.
Flowers: Deep pink, unisexual, clustered in panicle-like inflorescences,
Fruit/seed: Triangular nut 1–2 mm long, with pink or purplish papery valves, September.
Dispersal, establishment & growth: Diaspore: nut, dispersed by wind, water and gravity.
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to N Africa–Pakistan.
Botanical subregions: CC NWS CWS NWP SWP NFWP; Qld, NT, S.A., W.A.
Distribution Sydney area: Localised.
Select locations: CC: Concord (1966).

Habitat

Habitat: Rubbish tip.
Altitude: 0–50 m **Annual rainfall:** 1000 mm
Typical local abundance:
Vegetation:
Substrate:
Exposure: Full sun.

Conservation

Conservation: Locally naturalised at Concord 1966–86.

Acetosella vulgaris * POLYGONACEAE

Sorrel, Sheep Sorrel

Life history

Growth form: Slender, erect herb 10–50 cm high, with rosette of leaves and flowering stems. Horizontal rhizomatous rooting habit (Archer & Auld 1982). Horizontal roots often mistaken for rhizomes (Holm et al. 1997).
Vegetative spread: Spreads by extensive underground root system forming loose rosettes (Auld & Medd 1987, Holm et al. 1997).
Longevity:
Primary juvenile period: Probably 10 months (P. Kubiak pers. comm.).
Flowers: Small, rusty red, male and female flowers usually on different plants, flowers at any time, peak October–November.
Fruit/seed: Triangular nut with numerous seeds, 1–1.5 mm long, October–December.

Dispersal, establishment & growth: Diaspore: seed, no special morphology for dispersal (McIntyre et al. 1995), a root fragment 1 cm long is sufficient for propagation (Holm et al. 1997). Dispersed in mud on cars (Wace 1977), vegetative survival from rhizome fragments cut by cultivation; 20% of seed can remain viable in soil for more than 10 years (Keys & Duncan 1989). Seed is carried by birds — 15% passes through intestinal tract of chickens without injury; germination of fresh seed 3–4 weeks, but all seeds germinate in 8 days following 4 months of dry storage; 3% seeds viable after soil storage 25 years (Holm et al. 1997); germination is increased by fluctuating temperature and is more likely in autumn and spring (Keys & Duncan 1989). Increased spread in heavily grazed areas as other forage is consumed (Holm et al. 1997). Dry summers followed by plentiful autumn rains favour recruitment.
Fire response:
Interaction with other organisms: Foodplant of Stubble Quail *Coturnix pectoralis* (Barker & Vestjens 1989, 1990). Unpalatable to stock animals (Holm et al. 1997). Leaves poisonous to stock (Harden 1990). Known to cause allergy in humans where density is high (Bass 1987).

Distribution

Status/origin: Exotic, probably native to Europe.
Botanical subregions: NC CC SC NT CT ST NWS CWS SWS SWP; Qld, Vic., Tas., S.A., W.A.
Distribution Sydney area: Widespread.
Select locations: **CC:** Beecroft, Centennial Park, Homebush, Leumeah, Menangle, Thirlmere.
CT: Bathurst (1907), Junction Reefs, Blackheath, Mt Werong, Hill Top, Robertson, Bundanoon.

Habitat

Habitat: Disturbed areas, roadsides, grassland, riverbanks.
Altitude: 0–1000 m **Annual rainfall:** 600–1200 mm
Typical local abundance: Frequent.
Vegetation: Pastures, disturbed sites.
Substrate: Sandy soils on sandstone, granites, sand dunes, low nutrients.Very tolerant of drought and low nutrient, acid soils (Keys & Duncan 1989, Holm et al. 1997).
Exposure: Full sun.

Conservation

Conservation: A competitive perennial weed of crops and pastures, but not invasive of bushland. Difficult to control because of its vigorous vegetative reproduction (Archer & Auld 1982), maximum herbicide control best 2–6 weeks after autumn rain (Keys & Duncan 1989).

Emex australis * POLYGONACEAE

Spiny Emex, Three-cornered Jacks, Doublegee.

Life history

Growth form: Vigorous herb with hollow, prostrate stems to 75 cm long, which may be erect where supported by surrounding plants (Gilbey 1987, Gilbey et al. 1998). Deep fleshy taproot (Parsons & Cuthbertson 1992).
Vegetative spread: No.
Longevity: 1 year.
Primary juvenile period: Less than 1 year.
Flowers: Inconspicuous male and female flowers separate, on same plant, October–December.
Fruit/seed: Hard, woody, triangular nut with 3 sharp spines, with one seed, mature September–December; up to 1100 seeds have been recorded on individual plants (Parsons & Cuthbertson 1992). Can produce 120–1100 seeds per plant, reducing with increasing plant density (Gilbey et al. 1998).

Dispersal, establishment & growth: Diaspore: fruit, dispersed by attachment of spines to shoes, tyres, feet of animals, contamination of fodder, and by water. Most recruitment and seed production occurs during the first growing season following introduction; burial of seed promotes germination; seed populations comprise 3 components enabling spread of colonising effort over a number of seasons: annual cyclic dormancy, non-dormancy and continuous dormancy (Panetta & Randal 1994) but this is apparently determined by environmental conditions (Panetta & Randal 1993). Seed germinates at any time of year when moisture is available, forming a rosette from which long trailing stems are produced (Parsons & Cuthbertson 1992). Plants die off as moisture decreases in summer. Seed remains viable in soil 4–5 years (Markham 1985).
Fire response: Killed.
Interaction with other organisms: Birds eat seeds; seed found in seabird rookeries (Gilbey et al. 1998). Rodents destroy many seeds (Parsons & Cuthbertson 1992). Out-competed by other weeds *Trifolium subterranean* and *Hordeum glaucum* (Panetta & Randall 1994). Spiny fruit can cause lameness in animals (Harden 1990), sheep develop blackleg from infected wounds of feet, and in badly affected areas working dogs are fitted with leather boots (Markham 1985).

Distribution

Status/origin: Native of Mediterranean region.
Botanical subregions: NC CC SC ST NWS CWS SWS NWP SWP NFWP SFWP; Vic., Tas., W.A.
Distribution Sydney area: Widespread.
Select locations: CC: Yarramalong, Maroubra, La Perouse, Parramatta, Emu Plains (1894), Campbelltown, Menangle Park.

Habitat

Habitat: Pastures, gardens.
Altitude: 0–200 m **Annual rainfall:** 700–1400 mm
Typical local abundance: Occasional.
Vegetation: Pastures.
Substrate: Sandy and loamy soil, medium nutrients.
Exposure: Full sun.

Conservation

Conservation: Serious weed of pasture and cultivation, but not invasive of bushland. Difficult to eradicate; persistence due to its well developed seed dormancy (Gilbey 1987). Control by burning of seeding plants, with follow-up killing of seedlings for a number of years, and use of herbicides (Parsons & Cuthbertson 1992).

Muehlenbeckia costata POLYGONACEAE

Life history

Growth form: Scrambler with decumbent stems; flowering stems erect to 50 cm high.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Fleshy.
Fruit/seed: Shiny, black roundish nut 2–3 mm long
Dispersal, establishment & growth:
Fire response: Usually seen for a short time after fire — a 'fire weed' (K. Wilson pers. comm.).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NT CT; Qld.
Distribution Sydney area: Lithgow.
Select locations: CT: Lithgow.

Habitat

Habitat: Rocky sites at high altitudes.
Altitude: 800–1000 m **Annual rainfall:** 800–1000 mm
Typical local abundance:
Vegetation:
Substrate:
Exposure: Full sun.

Conservation

Conservation: One old dubious record for Lithgow, not refound despite searches. Southern geographical limit (K. Wilson pers. comm.).

Muehlenbeckia gracillima POLYGONACEAE

Life history

Growth form: Slender climber, with stems to 2 m long arising from a carrot-like rootstock and arrowhead-shaped leaves (Jones & Gray 1988).
Vegetative spread: Some stems rooting at nodes.
Longevity:
Primary juvenile period:
Flowers: At any time of year.
Fruit/seed: Nut 2.5 mm long, black, November–April.
Dispersal, establishment & growth: Diaspore: fruit, possibly bird-dispersed at maturity.
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC CC SC; Qld.
Distribution Sydney area: Coastal ranges.
Select locations: CC: Dora Creek, Colo River, Mooney Mooney Creek, Maroota, Longneck Lagoon, Ermington, Waterfall, Douglas Park, Mt Keira, Lake Illawarra, Barren Grounds, Berry.

Habitat

Habitat: Riverbanks.
Altitude: 0–500 m **Annual rainfall:** 700–1600 mm
Typical local abundance: Occasional.
Vegetation: Moist open-forest e.g. with *Eucalyptus deanei, Acacia elata*; riparian e.g. with *Acmena smithii, Rapanea howittiana, Smilax australis, Stellaria flaccida.*
Substrate: Basalt, shale, sandy alluvial fertile soils. Water table mostly low, moisture supply intermittent, fresh.
Exposure: Light shade.

Conservation

Conservation: Conservation status unknown.

Muehlenbeckia rhyticarya POLYGONACEAE

Life history

Growth form: Erect or decumbent low shrub to 1.5 m high, with red-brown stems.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Greenish yellow, July–October.
Fruit/seed: Black triangular nut 3–5 mm long
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC CC SC NT CT ST NWS CWS; Qld, Vic.
Distribution Sydney area:
Select locations: **CC:** Nortons Basin, Erskine Creek, Thirlmere. **CT:** Mt Darcy, Kanangra, Jenolan Caves, Yerranderie, Mt Jellore.

Habitat

Habitat: Moist situations in forest and on rocky slopes.
Altitude: 0–1000 m **Annual rainfall:** 900–1000 mm
Typical local abundance: Occasional.
Vegetation: Woodland e.g. with *Corymbia eximia, Eucalyptus punctata.*
Substrate: Sandy soils on sandstone, quartzite, slate.
Exposure:

Conservation

Conservation: Conservation status unknown.

Persicaria capitata * POLYGONACEAE

Japanese Knotweed

Life history

Growth form: Prostrate herb, with wiry knotted stems; ovate leaves with pink to red bands or blotches and short scattered hairs.
Vegetative spread: Prostrate stems root at nodes.
Longevity:
Primary juvenile period:
Flowers: Pink, April–October.
Fruit/seed: Dark brown to black triangular nut, April–December.
Dispersal, establishment & growth: Vegetative dispersal as dumped garden refuse.
Fire response: Resprouted after high intensity fire (1/94) at Lane Cove, flowering in less than 6 months (P. Kubiak pers. comm.).
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to Asia. Introduced as ornamental.
Botanical subregions: NC CC.
Distribution Sydney area: Mainly suburban areas.
Select locations: **CC:** Baulkham Hills, Beecroft, Garigal NP (L.McD.), Northbridge (1958), Balgowlah, Royal NP, Woodford, Avon Dam.

Habitat

Habitat: Disturbed creek banks, wet soaks, roadside embankments.
Altitude: 0–500 m **Annual rainfall:** 1000–1400 mm
Typical local abundance: Frequent.
Vegetation: Weeds of disturbance.
Substrate: Sandy soils, alluvium.
Exposure: Medium shade to full sun.

Conservation

Conservation: Garden plant occasionally naturalised in urban bushland near drainage lines.

Persicaria decipiens POLYGONACEAE

Slender Knotweed

Life history

Growth form: Decumbent to ascending plant to 30 cm high. Upright when smaller but tends to sprawl as it grows higher; the elongated tapering leaves usually have a bold red to purple mark around the centre (Romanowski 1998).
Vegetative spread: Some spread from rooting at nodes. Resprouts after flooding.
Longevity: Probably 1–3 years depending on conditions.
Primary juvenile period:
Flowers: Pink, arranged in narrow spikes, November-June, peak February. Probably pollinated by honeybees, native bees, flies, wasps and small butterflies (P. Kubiak pers. comm.).
Fruit/seed: Nut, 1 mm long, Nov–June, peak March.
Dispersal, establishment & growth: Seeds dispersed as fruit matures. Appears to be a perennial colonising species that disperses readily but seldom dominates. Dies back in winter or during drought.
Fire response: Probably resprouts. Flowering in 5 months after high intensity fire (1/94) at Lane Cove and Narrabeen (P. Kubiak pers. comm.).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC CC SC NT CT ST NWS SWP; Qld, Vic., Tas., N.T., S.A., W.A., N.I., N.Z., Eur, Afr & SW Asia.
Distribution Sydney area: Coast, western Sydney and Moss Vale area.
Select locations: CC: Wyong, North Richmond, Dee Why, Lane Cove, La Perouse, East Hills, Regentville, Campbelltown, Bulli, Albion Park. **CT:** Moss Vale.

Habitat

Habitat: Creeks and wet places.
Altitude: 0–700 m **Annual rainfall:** 700–1600 mm
Typical local abundance: Frequent–occasional.
Vegetation: Herbland e.g. with other *Persicaria* species and *Paspalum distichum.*
Substrate: Wide range of sites, sandy alluvial soils to clay flats, low-medium nutrients. Water table mostly high, moisture supply continuous, some sites with saline influence.
Exposure: Mid shade to full sun.

Conservation

Conservation: Conservation status unknown.

Persicaria elatior POLYGONACEAE

Life history

Growth form: Erect herb to 90 cm.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Dark pink, January–February (limited data).
Fruit/seed: Nut lenticular 2–2.5 mm long, mature February–April (limited data). Dispersed at maturity.
Dispersal, establishment & growth: Diaspore: nut.
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC CC SC; Qld.
Distribution Sydney area: Robertson, Picton Lakes.
Select locations: CC: Robertson, Picton Lakes (only 2 records).

Habitat

Habitat: Riverbank, edge of lake after disturbance.
Altitude: 0–500 m **Annual rainfall:** 900–1600 mm
Typical local abundance: Frequent.
Vegetation: Riparian herbland e.g. with *Pseudonaphalium luteoalbum, Persicaria hydropiper.*
Substrate: Sandy, alluvial soil, medium nutrients. Water table mostly high, moisture supply intermittent, fresh.
Exposure:

Conservation

Conservation: Rare, listed under schedule II, NSW Threatened Species Conservation Act 1995, coded 3V on national rare species list (Briggs & Leigh 1996).

Persicaria hydropiper POLYGONACEAE

Water Pepper

Life history

Growth form: Erect or ascending herb. Grows to 1 m high, with elongated, tapering leaves similar to *P. decipiens*, but unmarked (Romanowski 1998). Leaves and stems taste acrid or peppery (Holm et al. 1997).
Vegetative spread: Generally not, though stems in contact with soil can root at nodes (Holm et al. 1997).
Longevity: Short-lived, 1–2 years. By May, plants reddish brown autumnal colour in sunny area, dead plants in shaded area. Only exceptions were seedlings at Reedy Lagoon which were still green and flowering obviously about 3-4 months old. This species may be biennial (D. Benson)
Primary juvenile period: 3 months.
Flowers: White to greenish tinged with pink, December–May, peak March.
Fruit/seed: Nut, January–April, peak March. Dispersed at maturity.
Dispersal, establishment & growth: Diaspore: nut, probably water or bird-dispersed. Most likely species to colonise low lying sites. Short-term dormancy, germinates in autumn in wet ground and a flush of growth occurs with warmer weather, plants grow to 1 m tall and can flower in 3–4 months, die back in winter but may resprout in spring after mild conditions (Howell et al. 1995). Seeds reported viable after 50 years buried in soil (Holm et al. 1997).
Fire response:
Interaction with other organisms: Extensive leaf damage by leaf-eating beetles observed in April 1992 (Cattai DHB). Foodplant of Black Swan *Cygnus atratus*, Pacific Black Duck *Anas superciliosa*, Grey Teal *Anas gibberifrons* (Barker & Vestjens 1989,1990).

Distribution

Status/origin: Native.
Botanical subregions: NC CC SC NT CT ST NWS CWS SWS SWP; Qld, Vic., W.A.
Distribution Sydney area: Widespread.
Select locations: CC: Wyong, Cattai, Epping, Doonside, Coxs River, Wollongong, Berry.
CT: Rydal, Mullion Creek, Belubula River, Wingecarribee Swamp, Bowral.

Habitat

Habitat: Riverbands and creeks, semi-aquatic.
Altitude: 0–1100 m **Annual rainfall:** 700–1600 mm
Typical local abundance: Frequent–occasional.
Vegetation: Herbland with other *Persicaria* species e.g. *P. lapathifolia.*
Substrate: Sandy alluvial flats and banks, medium nutrients. Water table permanently high to mostly high, moisture supply intermittent, fresh. Often in acid soils (Holm et al. 1997).
Exposure: Sheltered, light shade to full sun. Possibly more shade tolerant than other *Persicaria* species, tolerates flooding.

Conservation

Conservation: Conservation status unknown.

Persicaria lapathifolia POLYGONACEAE

Pale Knotweed

Life history

Growth form: Erect or ascending plant 0.5 to 2 m high. ? Annual or short-lived perennial. The hollow stems are swollen above each node (Holm et al. 1997).
Vegetative spread: Some rooting at nodes but spread generally limited.
Longevity: 1–2 years.
Primary juvenile period:
Flowers: Pink, usually pendulous, in densely packed spikes (Romanowski 1998), October–April, peak February–March. Self-pollinated or insect pollinated (Holm et al. 1997).
Fruit/seed: Nut, 2 mm long, mature November–April, peak February–March. One plant can produce more than 19 000 seeds when growing without competition (Holm et al. 1997). Seed weight 1.24 mg, germination 11% within 30 days (Shipley & Parent 1991).
Dispersal, establishment & growth: No particular morphology for dispersal (McIntyre et al. 1995). Seed dispersed as fruit matures. Germination rate of 63% maintained after storage in water for 60 months (Holm et al. 1997). Recruits from seed and resprouts after flooding, growing vigorously in summer/Autumn. Growth rate quick, growing up to 2 m in a month. Coloniser of open sites.
Fire response: Probably resprouts. Fruiting in 5 months after high intensity fire (1/94) at Narrabeen (P. Kubiak pers. comm.).
Interaction with other organisms: Seed eaten by Plumed Whistling Duck *Dendrocygna eytoni* (Barker & Vestjens 1989). Foodplant of Black Swan *Cygnus atratus*, Pacific Black Duck *Anas superciliosa*, Grey Teal *Anas gibberifrons* (Barker & Vestjens 1989,1990). Flowers visited by native bees possibly feeding on nectar (P. Kubiak pers. comm.).

Distribution

Status/origin: Native.
Botanical subregions: NC CC SC NT CT ST NWS CWS SWS NWP SWP NFWP SFWP; Qld, Vic., Tas., N.T., S.A., Eurasia, Afr.
Distribution Sydney area: Western Sydney, Coxs, Wollondilly and Shoalhaven Rivers.
Select locations: **CC:** Wisemans Ferry, Yarramundi, Toongabbie, Burwood, Doonside, Woolooware Bay, Thirlmere, Albion Park, Coomonderry Swamp. **CT:** Lowther, Kowmung River, Bungonia.

Habitat

Habitat: Alluvial river flats and swampy creeks.
Altitude: 0–800 m **Annual rainfall:** 700–1200 mm
Typical local abundance: Frequent–occasional.
Vegetation: Herbland with *Juncus usitatus* and other *Persicaria* species.
Substrate: Alluvial sand and gravel, fertile soil. Water table mostly high, moisture supply continuous, fresh.
Exposure: Full sun.

Conservation

Conservation: Conservation status unknown.

Persicaria maculosa * POLYGONACEAE

Redshank, Jesus Plant

Life history

Growth form: Herb 40–60 cm high, often with a woody rootstock, leaves often with purplish blotches and hairy veins and margins.
Vegetative spread:
Longevity: 1 year (Holm et al. 1997).
Primary juvenile period: Flowering 6 weeks after germination (Holm et al. 1997).
Flowers: Pink to whitish, March. Very little nectar produced; almost exclusively self-pollinated (Holm et al. 1997).
Fruit/seed: Nut 2 mm long. One plant may produce more than 4 000 seeds; seed weight 1.65–3.91 mg (Holm et al. 1997).
Dispersal, establishment & growth: Diaspore: seed, water-dispersed. Germination of seed buried in soil 30 years, 9%, but none viable after 40 years (Holm et al. 1997).
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to Europe.
Botanical subregions: SC NT CT ST NWS; Vic., Tas.
Distribution Sydney area:
Select locations: CC: Wingecarribee Reservoir Lookout (1992).

Habitat

Habitat: Weedy sites.
Altitude: 690 m **Annual rainfall:** 1600 mm
Typical local abundance: Occasional.
Vegetation:
Substrate:
Exposure:

Conservation

Conservation: Reported in RBG nursery in 1987 and thought to have come in peat from Germany. Recent records from weedy sites and grassed parkland. Ability to invade natural habitats unknown.

Persicaria orientalis POLYGONACEAE

Princes Feathers

Life history

Growth form: Erect herb 1–2 m high.
Vegetative spread: Probably no vegetative spread.
Longevity: Less than 5 years.
Primary juvenile period:
Flowers: Deep pink, January–May, peak March.
Fruit/seed: Nut 2–3 mm long, dispersed at maturity.
Dispersal, establishment & growth: Probably germinates in drying mud.
Fire response:
Interaction with other organisms: Seed eaten by Plumed Whistling Duck *Dendrocygna eytoni* (Barker & Vestjens 1989,1990).

Distribution

Status/origin: Native.
Botanical subregions: NC CC SC NWS CWS SWS NWP SWP; Qld, NT, Asia.
Distribution Sydney area: Western Sydney and Illawarra.
Select locations: CC: Port Jackson (1802), Longneck Lagoon, Windsor, Chipping Norton, Doonside, Campbelltown, Albion Park, Coomonderry Swamp, Cambewarra.

Habitat

Habitat: Edges of swamps.
Altitude: 0–200 m **Annual rainfall:** above 700 mm
Typical local abundance: Occasional.
Vegetation: Herbland e.g. *Juncus usitatus, Persicaria hydropiper, P. lapathifolium, Melaleuca linariifolia.*
Substrate: Floodplain alluvium, medium-nutrient soil. Water table mostly high, moisture supply intermittent, fresh.
Exposure: Full sun.

Conservation

Conservation: Vulnerable in Western Sydney (James et al. 1999). Conservation status elsewhere unknown.

Persicaria praetermissa POLYGONACEAE

Life history

Growth form: Herb with creeping stems. Often semi-upright to 1 m high; leaves shaped like elongated arrow-heads (Romanowski 1998).
Vegetative spread: Probably to a metre.
Longevity: Indefinite.
Primary juvenile period:
Flowers: Pink, in slender spikes, November– March, peak January.
Fruit/seed: November–March, peak January.
Dispersal, establishment & growth: Seed dispersed at maturity.
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC CC SC NT CT ST SWS; Vic., Asia.
Distribution Sydney area: Widespread.
Select locations: CC: Wyong Creek, Burralow Swamp, Broadwater Swamp, Annangrove, Hornsby, Menangle, Shoalhaven. **CT:** , Coxs River, Wingecarribee, Long Swamp (Kodela 1992).

Habitat

Habitat: Creeks, riverbanks and swamps, sometimes disturbed sites.
Altitude: 0–800 m **Annual rainfall:** above 800 mm
Typical local abundance: Frequent.
Vegetation: Semi-permanent and seasonal wetland e.g. with *Eleocharis sphacelata, Persicaria hydropiper, Melaleuca linariifolia, Persicaria decipiens, P. lapathifolium.* Upland mire (Kodela 1992).
Substrate: Sandy or gravelly alluvium, medium to low nutrient soil, poorly-drained. Water table permanently high–mostly high, moisture supply intermittent, fresh.
Exposure: Indifferent to exposure, light shade to no shade. Perhaps more in open than *P. strigosa.* Possibly some salt tolerance.

Conservation

Conservation: Vulnerable in Western Sydney (James et al. 1999). Conservation status elsewhere unknown.

Persicaria prostrata POLYGONACEAE

Creeping Knotweed

Life history

Growth form: Decumbent herb, often with woody rootstock.
Vegetative spread: Probably spreads vegetatively.
Longevity:
Primary juvenile period:
Flowers: Green–cream, in spikes, flowerheads more compact than other species (Romanowski 1998), November–April, peak March–April.
Fruit/seed: Nut 1.5–2 mm, mature January–March, dispersed at maturity.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms: Foodplant of Freckled Duck *Stictonetta nervosa,* Pacific Black Duck *Anas superciliosa* (Barker & Vestjens 1989,1990).

Distribution

Status/origin: Native.
Botanical subregions: CC SC NT CT ST NWS CWS SWS NWP SWP; Qld, Vic., Tas., N.T., S.A., W.A., NZ
Distribution Sydney area: Widespread.
Select locations: CC: Wondabyne, Richmond, Casula, Warrimoo, Yanderra, Nowra.
CT: Bathurst, Winburndale, Orange, Blayney, Mittagong.

Habitat

Habitat: Stream banks, disturbed riverbanks, roadsides, drains.
Altitude: 0–900 m **Annual rainfall:** 700–1400 mm
Typical local abundance: Frequent–occasional.
Vegetation: Herbland, e.g. with *Geranium retrosum, Viola hederacea, Persicaria strigosum, Cirsium vulgare.*
Substrate: Sandy soil medium nutrients e.g. granite, alluvium, disturbed. Water table mostly high, moisture supply intermittent, fresh.
Exposure: Light shade to full sun.

Conservation

Conservation: Vulnerable in Western Sydney (James et al. 1999). Conservation status elsewhere unknown.

Persicaria strigosa POLYGONACEAE

Life history

Growth form: Perennial herb with creeping stems.
Vegetative spread: Vegetative spread probably to 2 m.
Longevity: Indefinite.
Primary juvenile period:
Flowers: December–May, peak December.
Fruit/seed: Nut 3 mm long, matures December–March, peak March, dispersed at maturity.
Dispersal, establishment & growth: Diaspore: nut, probably water or bird-dispersed.
Fire response: Probably resprouts. Flowering in 5 months after high intensity fire (1/94) at Lane Cove (P. Kubiak pers. comm.).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC CC CT; Qld, Asia, Malesia.
Distribution Sydney area: Widespread.
Select locations: CC: Mangrove Creek, Shane Park, Narrabeen, Mascot, Centennial Park, Menangle, Otford, Kiama. **CT:** Glanmire, Moss Vale.

Habitat

Habitat: Creek banks and open swampy areas.
Altitude: 0–750 m **Annual rainfall:** above 700 mm
Typical local abundance: Frequent.
Vegetation: Riparian herbland.
Substrate: Sandy to loamy soil, alluvium and dune sand, low nutrients. Water table permanently high–mostly high, poorly drained.
Exposure:

Conservation

Conservation: Vulnerable in Western Sydney (James et al. 1999). Conservation status elsewhere unknown.

Persicaria subsessilis POLYGONACEAE

Hairy Knotweed

Life history

Growth form: Stout decumbent hairy herb.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: March, June, December (inadequate data).
Fruit/seed: Nut 2–2.5 mm long.
Dispersal, establishment & growth: Diaspore: nut.
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC CC SC; Qld, Vic., Tas., W.A., N.G., N Cal.
Distribution Sydney area: Western Sydney.
Select locations: **CC:** Cheltenham, Shane Park, Narellan.

Habitat

Habitat: Creek banks.
Altitude: 0–200 m **Annual rainfall:** 800–1100 mm
Typical local abundance:
Vegetation: Weedy wetland vegetation e.g. *Rumex, Ranunculus, Juncus.*
Substrate: Sandy alluvium, medium nutrients.
Exposure:

Conservation

Conservation: Rare, 3 specimens only in Herbarium collection. Vulnerable in Western Sydney (James et al. 1999).

Polygonum arenastrum * POLYGONACEAE

Wireweed

Life history

Growth form: Prostrate to decumbent herb, usually mat-forming, stems often rooting at nodes, with stems to 100 cm long.
Vegetative spread: Decumbent stems rooting.
Longevity: Possibly annual.
Primary juvenile period:
Flowers: Pink, March–June.
Fruit/seed: Brown to dark brown nut 1–2 mm long, March–June.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms: Leaves can cause dermatitis; seed can cause enteritis in stock (Harden 1990).

Distribution

Status/origin: Exotic, native to Europe.
Botanical subregions: NC CC SC NT CT ST NWS CWS SWS NWP SWP NFWP SFWP; Qld, Vic., Tas., S.A.
Distribution Sydney area:
Select locations: **CC:** Richmond, Wahroonga, Cheltenham, Domain (1902), Burwood, Emu Plains, Glenfield, Nowra. **CT:** O'Connel, Orange, Bowral, Bathurst, Robertson.

Habitat

Habitat: Riverbanks, roadsides, footpaths.
Altitude: 0–1000 m **Annual rainfall:** 700–1400 mm
Typical local abundance: Frequent.
Vegetation:
Substrate: Clay soils on shale, sandy alluvium, medium nutrients. Recorded on saline sites in western NSW (Semple 1993).
Exposure:

Conservation

Conservation: Common weed of disturbed sites.

Polygonum aviculare * POLYGONACEAE

Wireweed

Life history

Growth form: Prostrate to decumbent herb, usually mat-forming, with stems to 100 cm long.
Vegetative spread: Stems often rooting at nodes.
Longevity:
Primary juvenile period:
Flowers: White, November–March. Usually self-pollinated (Holm et al. 1997).
Fruit/seed: Dark brown nut 2–3 mm long, November–May. One plant can produce more than 6000 seeds if competition is light (Holm et al. 1997).
Dispersal, establishment & growth: No particular morphology for dispersal (McIntyre et al. 1995), dispersed in mud on cars (Wace 1977), dispersed by birds, animals, human activity (Holm et al. 1997).
Fire response:
Interaction with other organisms: Foodplant of Black Swan *Cygnus atratus*, Pacific Black Duck *Anas superciliosa*, Grey Teal *Anas gibberifrons*, Stubble Quail *Coturnix pectoralis*, and Freckled Duck *Stictonetta nervosa*, seed eaten by Singing Bushlark *Mirafra javanica* (Barker & Vestjens 1989,1990). Seed eaten by Crimson Rosella *Platycercus elegans* (Lepschi 1993). Leaves can cause dermatitis; seed can cause enteritis in stock (Harden 1990).

Distribution

Status/origin: Exotic.
Botanical subregions: NC CC SC CT ST NWS CWS SWS NWP SWP SFWP; Qld, Vic., Tas., W.A.
Distribution Sydney area: Widespread.
Select locations: **CC:** Pennant Hills, Blackwattle Bay, Burwood, Arncliffe, Emu Plains, Glenfield, Nowra. **CT:** Orange, Bathurst, Junction Reefs, Burrawang.

Habitat

Habitat: Pastures, gardens.
Altitude: 0–800 m **Annual rainfall:** 600–1400 mm
Typical local abundance: Frequent.
Vegetation: Pastures.
Substrate: Clay soils on shale. Recorded on saline sites in western NSW (Semple 1993).
Exposure:

Conservation

Conservation: Weed of pastures.

Polygonum patulum POLYGONACEAE

Tree Hogweed

Life history

Growth form: Erect herb 20–100 cm high.
Vegetative spread: No.
Longevity:
Primary juvenile period:
Flowers:
Fruit/seed: Shiny brown nut 2–3 mm long, December–January.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to Europe.
Botanical subregions: CC NT NWS CWS NWP SFWP; Qld, Vic.
Distribution Sydney area: Parramatta River foreshores.
Select locations: CC: Gladesville (1976), Ermington (1986).

Habitat

Habitat:
Altitude: 0–50 m **Annual rainfall:** 1000–1200 mm
Typical local abundance: Rare.
Vegetation: Edge of saltmarsh.
Substrate: Estuarine alluvium.
Exposure:

Conservation

Conservation: Rare, conservation status unknown.

Polygonum plebeium POLYGONACEAE

Small Knotweed

Life history

Growth form: Prostrate to decumbent herb, usually mat-forming, with stems to 15 cm long.
Vegetative spread: Stems often rooting at nodes.
Longevity:
Primary juvenile period:
Flowers: Pink, white, November–March.
Fruit/seed: Dark brown to black, smooth and shiny nut 1–2 mm long, March.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC CC CT NWS CWS NWP SWP NFWP SFWP; Qld, Vic, NT SA, NZ, Malesia, Asia.
Distribution Sydney area:
Select locations: CC: Wondabyne, Richmond, Dennistone, Liverpool, Campbelltown, Menangle Park. **CT:** Bathurst.

Habitat

Habitat: Railway lines, wetland margins.
Altitude: 0–800 m **Annual rainfall:** 600–1200 mm
Typical local abundance: Frequent–occasional.
Vegetation: Edges of wetland.
Substrate: Reported along railway lines, suggesting possible link with basalt used as ballast.
Exposure:

Conservation

Conservation: Vulnerable in Western Sydney (James et al. 1999). Conservation status elsewhere unknown.

Reynoutria japonica * POLYGONACEAE

Life history

Growth form: Perennial herb 1–2 m high; stems often glaucous or red-brown, numerous and thicket-forming.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Whitish, November.
Fruit/seed: Nut 2–4 mm long.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Naturalised exotic, native to Japan. Introduced as ornamental.
Botanical subregions: CC ?ST SWS.
Distribution Sydney area:
Select locations: **CC:** Wahroonga (1970–1986).

Habitat

Habitat: Roadside.
Altitude: 0–200 m **Annual rainfall:** 1400 mm
Typical local abundance:
Vegetation:
Substrate:
Exposure:

Conservation

Conservation: Cultivated in gardens, locally naturalised at one site in Wahroonga 1970–1986.

Reynoutria sachalinensis * POLYGONACEAE

Life history

Growth form: Perennial herb 2–4 m high, with greenish, bamboo-like stems forming a dense thicket.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Greenish or yellow, November–December.
Fruit/seed: Nut 2–3 mm long.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to Asia. Introduced as ornamental.
Botanical subregions: CT.
Distribution Sydney area:
Select locations: **CT:** Penrose.

Habitat

Habitat: Orchard.
Altitude: 700 m **Annual rainfall:** 900 mm
Typical local abundance:
Vegetation:
Substrate:
Exposure:

Conservation

Conservation: Cultivated in gardens, locally naturalised at Penrose (1949–1956) but did not appear to be spreading.

Rumex brownii POLYGONACEAE

Swamp Dock

Life history

Growth form: Herb 50–80 cm high, with slender, erect stems and basal leaves. Stems reddish green, sparsely branched, with a short underground stem, and below, a thick often twisted, branched taproot (Parsons & Cuthbertson 1992).
Vegetative spread: No.
Longevity: Probably 1–5 years.
Primary juvenile period: Less than 1 year.
Flowers: Greenish red, clustered, August–March.
Fruit/seed: Nut enclosed by valves 2.5–4 mm long, with c. 10 hooked teeth, shed at maturity, November–March. Seed a rusty brown, 3-sided nutlet 1.5 mm long (Parsons & Cuthbertson 1992).
Dispersal, establishment & growth: Diaspore: fruit, dispersed by adhesion (McIntyre et al. 1995) on clothing, animals etc. Root fragments are capable of regeneration; seed germinates throughout the year when moisture is available, mainly autumn and spring; basal rosette grows in winter, flowering from spring to early summer when aerial growth dies back leaving erect stems laden with hooked fruit; regrowth commences during winter–spring (Parsons & Cuthbertson 1992). Coloniser of disturbed sites, minor weed of gardens and pastures.
Fire response: Resprouted after high intensity fire (1/94) at Lane Cove; secondary juvenile period less than 5 months (P. Kubiak pers. comm.).
Interaction with other organisms: Oxalate accumulation in stems is toxic to animals if large amount is consumed (Parsons & Cuthbertson 1992).

Distribution

Status/origin: Native.
Botanical subregions: NC CC SC NT CT ST NWS CWS SWS NWP SWP SFWP; Qld, Vic., Tas., N.T., S.A., W.A.
Distribution Sydney area: Mainly western Sydney.
Select locations: **CC:** Beecroft, Burwood, Richmond, Penrith, Glenfield, Picton, Gerringong, Kangaroo Valley. **CT:** Junction Reefs, Orange, Kowmung River.

Habitat

Habitat: Riverflats, open-forest, disturbed sites, gardens.
Altitude: 0–800 m **Annual rainfall:** 700–1200 mm
Typical local abundance: Frequent–occasional.
Vegetation: Open-forest e.g. with *Eucalyptus crebra, E. tereticornis, E. moluccana, Bursaria spinosa;* grassland e.g. with *Danthonia racemosa.*
Substrate: Clay soils from Wianamatta shale, alluvial soils, medium nutrients, possibly with calcium influence.
Exposure: Full sun.

Conservation

Conservation: Vulnerable in Western Sydney (James et al. 1999). Conservation status elsewhere unknown.

Rumex conglomeratus * POLYGONACEAE

Clustered Dock

Life history

Growth form: Glabrous perennial herb 60–150 cm high, with a thick taproot, branching below (Parsons & Cuthbertson 1992).
Vegetative spread:
Longevity:
Primary juvenile period: Less than 1 year at Lane Cove (P. Kubiak pers. comm.).
Flowers: Small, reddish green, in clusters, November–January.
Fruit/seed: Red-brown 3-sided nut enclosed in valves 2–3 mm long, with red-brown 3-sided seed about 1 mm long (Parsons & Cuthbertson 1992). Mature November–January.
Dispersal, establishment & growth: Diaspore: fruit, dispersed by wind, water, animals and humans (Parsons & Cuthbertson 1992), in mud on cars (Wace 1977). Crown and taproot capable of regeneration and spread when fragments are moved in soil; young plants are capable of progagating from buds on crown or upper taproot 30–50 days after germination; seed with variable dormancy so germination is intermittent, with main germination in autumn and spring; seedlings overwinter with a rosette, aerial growth is slow as the taproot develops; flowers are produced in first season if uncrowded or second season in dense stands (Parsons & Cuthbertson 1992).
Fire response:
Interaction with other organisms: Suspected of poisoning sheep in NSW (Parsons & Cuthbertson 1992).

Distribution

Status/origin: Exotic, native to Europe and SW Asia, almost cosmopolitan weed.
Botanical subregions: NC CC SC NT CT ST CWS SWS SWP; Qld, Vic., Tas., S.A., W.A.
Distribution Sydney area: Widespread.
Select locations: **CC:** Wyong Creek, Hornsby, Dennistone, Parramatta, Wallacia, Campbelltown, Bulli (1890), Shellharbour, Jamberoo (1899). **CT:** Wildes Meadow.

Habitat

Habitat: Moist areas along roadsides, disturbed areas, pastures.
Altitude: 0–660 m **Annual rainfall:** 900–1600 mm
Typical local abundance: Frequent–occasional.
Vegetation: Woodland e.g with *Eucalyptus moluccana, E. tereticornis;* riparian scrub e.g. with *Melaleuca linariifolia, M. styphelioides,* also saline marsh.
Substrate: Clay soils on shale, basalt, alluvium, medium to high nutrients.
Exposure:

Conservation

Conservation: Weed of cutivation and pasture. Control by use of herbicides or digging out roots at least 20 cm below surface to prevent regeneration; small seedlings can be controlled by cultivation (Parsons & Cuthbertson 1992).

Rumex crispus * POLYGONACEAE

Curled Dock

Life history

Growth form: Glabrous, perennial herb 30–150 cm high, with a thick underground stem or crown and a long slender taproot often to a depth of 3 m (Parsons & Cuthbertson 1992).
Vegetative spread: No (McIntyre et al. 1995).
Longevity:
Primary juvenile period: 1–2 years.
Flowers: Greenish red in clusters, August–February.
Fruit/seed: Deep reddish-brown 3-sided nut enclosed in valves 3.5–6 mm long, with dark red-brown angular seeds 2 mm long, mature November–March; seeds ripen 16–20 days after flowers open and may be held in seedheads on dead stems for several months (Parsons & Cuthbertson 1992).
Dispersal, establishment & growth: Diaspore: fruit, dispersed by wind, water, animals and humans (Parsons & Cuthbertson 1992), morphology for wind dispersal (McIntyre et al. 1995), dispersed in mud on cars (Wace 1977). Crown and taproot capable of regeneration and spread when fragments are moved in soil; young plants are capable of progagating from buds on crown or upper taproot 30–50 days after germination (Parsons & Cuthbertson 1992).
Seed with variable dormancy so germination is intermittent, with main germination in autumn and spring; seedlings overwinter with a rosette, aerial growth is slow as the taproot develops; flowers are produced in first season if uncrowded or second season in dense stands (Parsons & Cuthbertson 1992). Coloniser.
Fire response: Resprouted after high intensity fire (1/94) at Lane Cove (P. Kubiak pers. comm.).
Interaction with other organisms: Known to cause allergy in humans where density is high (Bass 1987).

Distribution

Status/origin: Naturalised exotic, native to Europe & SW Asia.
Botanical subregions: NC CC SC NT CT ST NWS CWS SWS NWP SWP NFWP SFWP; Qld, Vic., Tas., N.T., S.A., W.A.
Distribution Sydney area:
Select locations: **CC:** Eastwood, Parramatta, Balgowlah, Centennial Park, Kogarah (1899), Emu Plains, Narellan, Campbelltown, Appin. **CT:** Orange, Mittagong.

Habitat

Habitat: Creeks, low-lying areas, waste places.
Altitude: 0–1000 m **Annual rainfall:** 700–1200 mm
Typical local abundance: Frequent.
Vegetation: Woodland e.g. with *Eucalyptus moluccana, E. tereticornis.*
Substrate: Clay soils on shale, medium nutrients.
Exposure:

Conservation

Conservation: Weed of disturbed sites. Control by use of herbicides or digging out roots at least 20 cm below surface to prevent regeneration; small seedlings can be controlled by cultivation (Parsons & Cuthbertson 1992).

Rumex obtusifolius subsp. *obtusifolius* * POLYGONACEAE

Broadleaf Dock

Life history

Growth form: Perennial herb 60–100 cm high; hybrids occur with *R. crispus.*
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Small, clustered,
Fruit/seed: 3-sided nut enclosed in valves.
Dispersal, establishment & growth: Diaspore: fruit, dispersed by wind, water, animals and humans (Parsons & Cuthbertson 1992).
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Exotic, native of Europe & SW Asia.
Botanical subregions: NC CC SC NT CT ST SWS; Vic., S.A.
Distribution Sydney area: Widespread.
Select locations: CC: Yarramundi, Hornsby, Cooks River (1912), Macquarie Pass. **CT:** Leura, Moss Vale, Robertson, Kangaloon.

Habitat

Habitat: Moist places, riverbanks, roadsides.
Altitude: 0–1000 m **Annual rainfall:** 800–1200 mm
Typical local abundance: Frequent–occasional.
Vegetation: Weedy places, pasture.
Substrate: Sandy alluvium, medium nutrients, poorly-drained.
Exposure:

Conservation

Conservation: Weed of moist disturbed sites.

Rumex pulcher subsp. *pulcher* * POLYGONACEAE

Fiddle Dock

Life history

Growth form: Erect, glabrous, much branched perennial herb 30–100 cm high, with a thick taproot branching below (Parsons & Cuthbertson 1992).
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Small, reddish green in clusters,
Fruit/seed: Red-brown 3-sided nut enclosed in valves 4–6 mm long, with pale red-brown 3-sided seed 1.5 mm long.
Dispersal, establishment & growth: Diaspore: fruit, dispersed by wind, water, animals and humans; crown and taproot capable of regeneration and spread when fragments are moved in soil; young plants are capable of progagating from buds on crown or upper taproot 30–50 days after germination. Seed with variable dormancy so germination is intermittent, with main germination in autumn and spring; seedlings overwinter with a rosette, aerial growth is slow while the taproot develops; flowers are produced in first season if uncrowded or second season in dense stands (Parsons & Cuthbertson 1992).
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Exotic, native of Mediterranean & SW Asia.
Botanical subregions: CC SC SWS SWP; Vic., Tas., S.A., W.A.
Distribution Sydney area: Suburban areas.
Select locations: CC: Ashfield, Cooks River (1912), Concord, Kiama (1899), Jamberoo Pass.

Habitat

Habitat: Moist disturbed areas and roadsides.
Altitude: 0–100 m **Annual rainfall:** 1000–1400 mm
Typical local abundance:
Vegetation:
Substrate:
Exposure:

Conservation

Conservation: Occasional weed of cultivation, roadsides, disturbed areas. Control by use of herbicides or digging out roots at least 20 cm below surface to prevent regeneration; small seedlings can be controlled by cultivation (Parsons & Cuthbertson 1992).

Rumex tenax — POLYGONACEAE

Shiny Dock

Life history

Growth form: Erect perennial herb 15–50 cm high.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Small, clustered
Fruit/seed: 3-sided nut enclosed by valves 2.5–3.5 mm long.
Dispersal, establishment & growth: Dispore: fruit.
Fire response:
Interaction with other organisms: Foodplant of Black Swan *Cygnus atratus* (Barker & Vestjens 1989,1990).

Distribution

Status/origin: Native.
Botanical subregions: CC ST NWS CWS SWS NWP SWP NFWP SFWP; Qld, Vic., S.A., W.A.
Distribution Sydney area:
Select locations: CC: Kurrajong, Riverstone, Flemington.

Habitat

Habitat: Damp weedy areas.
Altitude: 0–200 m **Annual rainfall:** 700–1400 mm
Typical local abundance:
Vegetation:
Substrate: Clay soils on shale, medium nutrients.
Exposure:

Conservation

Conservation: A native species of drier Western Slopes and Plains that has probably been introduced with stock.

Calandrinia calyptrata — PORTULACACEAE

Life history

Growth form: Procumbent, succulent herb with stems to 20 cm long.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Pale pink.
Fruit/seed: Capsule 2–3 mm long, with 10–20 dark brown to red-brown seeds.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CC CT CWS SWS SWP; ?Qld, Vic., Tas., S.A., W.A.
Distribution Sydney area:
Select locations: CC: Ingleburn. CT: Hill Top.

Habitat

Habitat:
Altitude: 0–700 m **Annual rainfall:** 900 mm
Typical local abundance:
Vegetation:
Substrate: Sandy gravelly soils, often asssociated with granite.
Exposure:

Conservation

Conservation: Conservation status unknown.

Calandrinia eremaea PORTULACACEAE

Life history

Growth form: Decumbent, succulent herb with erect to spreading stems to 20 cm long.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: White, pale pink to purple.
Fruit/seed: Capsule 3–5 mm long, with more than 20 kidney-shaped seeds.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NT CT ST NWS CWS SWS NWP SWP NFWP SFWP; Qld, Vic., N.T., S.A., W.A.
Distribution Sydney area:
Select locations: **CT:** Jenolan Caves (1894), Barbers Creek (1900).

Habitat

Habitat:
Altitude: 700–1000 m **Annual rainfall:** 900–1100 mm
Typical local abundance:
Vegetation:
Substrate:
Exposure:

Conservation

Conservation: Rare, reported from a few old collections. Conservation status unknown.

Calandrinia menziesii * PORTULACACEAE

Life history

Growth form: Prostrate to decumbent succulent herb with stems to 25 cm long.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Purple.
Fruit/seed: Capsule 7–9 mm long, with numerous black seeds.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to N America.
Botanical subregions: NC CC SC CT ST CWS SWP; VIC, TAS, SA, WA,
Distribution Sydney area:
Select locations: **CC:** Richmond (1917), Waterfall (1980). **CT:** Goulburn (1925).

Habitat

Habitat:
Altitude: 0–700 m **Annual rainfall:** 700–1400 mm
Typical local abundance:
Vegetation:
Substrate:
Exposure:

Conservation

Conservation: Widely naturalised (Harden 1990), though there are only a few old collections.

Calandrinia pickeringii PORTULACACEAE

Life history

Growth form: Decumbent to ascending succulent herb with flowering stems to 20 cm long.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Pale pink, June–October.
Fruit/seed: Capsule about 3 mm long, with numerous dark red-brown to black seeds, April.
Dispersal, establishment & growth:
Fire response: Prolific seedlings in depressions on rock platform, after high-intensity fire at Yeomans Bay 1994 (L.McD.).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC CC SC ST; Qld.
Distribution Sydney area: Sporadic.
Select locations: **CC:** Yengo NP, East Kurrajong, Shellharbour.

Habitat

Habitat: Rock outcrops, logs.
Altitude: 0–400 m **Annual rainfall:** 1000–1200 mm
Typical local abundance: Occasional.
Vegetation: Open-forest e.g. with *Angophora costata, Eucalyptus piperita*; salt-tolerant coastal scrub.
Substrate: On sandstone, granite and basalt outcrops.
Exposure: Full sun to light shade.

Conservation

Conservation: Rare, conservation status unknown.

Montia fontana subsp. *chondrosperma* PORTULACACEAE

Life history

Growth form: Tufted annual herb, with ascending to erect stems to 20 cm long.
Vegetative spread: Sometimes stonloniferous.
Longevity:
Primary juvenile period:
Flowers: White.
Fruit/seed: Capsule 1–2 mm long, with black seeds.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CT ST SWS; Vic., Tas., S.A., N.Z., Eur, N & S Amer.
Distribution Sydney area: Orange.
Select locations: **CT:** Orange (1983).

Habitat

Habitat: Watercourses, swamps, bogs, marshes and wet grassland.
Altitude: 800 m **Annual rainfall:** 800–1000 mm
Typical local abundance:
Vegetation:
Substrate: Loamy soil on slate, moist.
Exposure:

Conservation

Conservation: Appears to be rare, conservation status unknown.

Neopaxia australasica PORTULACACEAE

Life history

Growth form: Semi-aquatic herb with stems to 30 cm long, rooting at nodes. In shallow waters may form a floating mat reaching out over deeper areas; leaves succulent (Romanowski 1998).
Vegetative spread: Stoloniferous, often forming dense mats at higher altitudes.
Longevity:
Primary juvenile period:
Flowers: White or pale pink, September–November.
Fruit/seed: Capsule about 2–3 mm long, with up to 3 shiny, black seeds.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: SC NT CT ST CWS SWS SWP; Vic., Tas., S.A., W.A., N.Z.
Distribution Sydney area: Tablelands.
Select locations: **CT:** Meadow Flat, Orange, Oberon, Edith, Mt Werong, Wingecarribee Swamp.

Habitat

Habitat: Moist areas including bogs, swamps streams.
Altitude: 680–1000 m **Annual rainfall:** 800–1600 mm
Typical local abundance: Frequent–occasional.
Vegetation: Sedge swamp e.g. with *Juncus, Carex, Ranunculus.*
Substrate: Peaty or clay soils, permanently moist, sometimes running water.
Exposure:

Conservation

Conservation: Locally restricted and vulnerable, conservation status unknown.

Portulaca oleracea PORTULACACEAE

Pigweed, Purslane

Life history

Growth form: Annual, sometimes perennial, prostrate to decumbent succulent herb, with reddish stems to 25 cm long and fleshy leaves.
Vegetative spread: Adventitious root development when plants are cut or broken (Gorske 1978).
Longevity: 1–2 years.
Primary juvenile period: Probably (?from seed) fruiting less than 4 months after high intensity fire (1/94) at Lane Cove (P. Kubiak pers. comm.).
Flowers: Yellow, in heads, August–March.
Fruit/seed: Capsule 3–6 mm long, with minute black seeds.
Dispersal, establishment & growth: No particular morphology for dispersal (McIntyre et al. 1995). Germination best with soil temperature 20°–30° C (Gorske 1978).
Fire response:
Interaction with other organisms: Seeds eaten by birds, Richard's Pipit *Anthus novaeseelandiae*, foodplant of Stubble Quail *Coturnix pectoralis* (Barker & Vestjens 1989, 1990) and butterfly larvae *Hypolimnas misippus* and *Junonia villida calybe* (Common & Waterhouse 1981). Heavily cropped by rabbits (P. Kubiak pers. comm.).

Distribution

Status/origin: Native.
Botanical subregions: NC CC SC CT NWS CWS NWP SWP NFWP SFWP; LHI, Qld, Vic., Tas., N.T., S.A., W.A., cosmop.
Distribution Sydney area: Widespread.
Select locations: **CC:** Freemans Reach, Berowra, Farm Cove, Kogarah, Flemington Saleyards, Emu Plains, Five Islands. **CT:** Bathurst.

Habitat

Habitat: Paddocks, cultivated areas.
Altitude: 0–700 m **Annual rainfall:** 600–1200 mm
Typical local abundance: Frequent.
Vegetation:
Substrate: Wide range of soil types (Cunningham et al. 1981), can survive drought (Gorske 1978).
Exposure: Full sun.

Conservation

Conservation: Grows as a weed in disturbed areas, common on cultivated land (Harden 1990).

Talinum paniculatum * PORTULACACEAE

Life history

Growth form: Erect annual herb or subshrub to 60 cm high, with tuberous roots.
Vegetative spread: No.
Longevity:
Primary juvenile period:
Flowers: Pink, spring–summer.
Fruit/seed: Capsule 3–5 mm, with numerous shiny black seeds c. 1 mm diam.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to N & S America. Introduced as ornamental.
Botanical subregions: NC CC SC CWS; Qld.
Distribution Sydney area: Sydney suburbs.
Select locations: **CC:** Cheltenham (1954), Strathfield (1949), Carringbah (1974).

Habitat

Habitat: Gardens, rockeries.
Altitude: 0–250 m **Annual rainfall:** 1000–1400 mm
Typical local abundance: Frequent.
Vegetation:
Substrate: Clay soil, persisting in crevices between rocks etc.
Exposure:

Conservation

Conservation: A garden escape, mainly naturalised in suburban areas.

Anagallis arvensis * **PRIMULACEAE**

Scarlet Pimpernel, Blue Pimpernel

Life history

Growth form: Annual or perennial herb, stems creeping to weakly erect, with opposite leaves.
Vegetative spread: No.
Longevity: 1–2 years.
Primary juvenile period:
Flowers: Red / orange and blue-flowered forms occur. Flowers September–December. Possibly pollinated by hoverflies (Syrphidae) (P. Kubiak pers. comm.).
Fruit/seed: Capsule, 5-ridged, 3–5 mm diam., October–December.
Dispersal, establishment & growth: Mechanism for dispersal undefined (McIntyre et al. 1995), dispersed in mud on cars (Wace 1977). Overwinters as soil-stored seedbank.
Fire response: Probably killed.
Interaction with other organisms: Shoots apparently eaten by rabbits (P. Kubiak pers. comm.).

Distribution

Status/origin: Exotic, native to Europe, W Asia, N Africa. Reported by Robert Brown to be introduced to Sydney by 1804 (Maiden 1909).
Botanical subregions: NC CC SC NT CT ST NWS CWS NWP SWP NFWP; LHI, Qld, Vic., Tas., S.A., W.A.
Distribution Sydney area: Widespread.
Select locations: **CC:** Colo River, Peats Crater, Beecroft, Castle Hill, Ashfield, St Marys, Baderys Creek, Five Islands, Bomaderry. **CT:** Mt Towinhingy, Medlow Bath, Abercrombie.

Habitat

Habitat: Pastures, disturbed sites, creekbanks, gardens.
Altitude: 0–1000 m **Annual rainfall:** 700–1400 mm
Typical local abundance: Frequent–occasional.
Vegetation: Associated with short-lived weeds of cultivation etc.
Substrate: Clay soils on shale, basalt, sandy soils on alluvium. Recorded on saline sites in western NSW (Semple 1993).
Exposure:

Conservation

Conservation: A short-lived weed of disturbed sites.

Lysimachia vulgaris var. *davurica* — PRIMULACEAE

Yellow Loosestrife

Life history

Growth form: Erect herb to 80 cm high
Vegetative spread: Spreads by rhizomes/stolons.
Longevity:
Primary juvenile period:
Flowers: Yellow, white, red or blue, February.
Fruit/seed: Capsule, February–March.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CT; Japan, NE Asia.
Distribution Sydney area: Recorded at Wingecarribee Swamp only
Select locations: CT: Wingecarribee Swamp.

Habitat

Habitat: Aquatic to drier but well-watered situations (Kodela 1998).
Altitude: 680 m **Annual rainfall:** 1600 mm
Typical local abundance: Frequent.
Vegetation: Sedgeland e.g. with *Carex, Phragmites australis, Lythrum salicaria, Geranium neglectum, Lycopus australis.*
Substrate: Peat to loam and possibly sandy soils, low nutrients, periodically water-logged.
Exposure: Full sun.

Conservation

Conservation: Rare, listed as Endangered under Schedule I of the NSW Threatened Species Conservation Act and currently threatened by the recent collapse and drainage of Wingecarribee Swamp, the only known site for this species in Australia.

Samolus repens — PRIMULACEAE

Creeping Brookweed

Life history

Growth form: Erect to creeping herb with stems 5–60 cm long. Leaves thick, leathery and less than 1 cm across (Romanowski 1998).
Vegetative spread: Stoloniferous and rhizomatous.
Longevity:
Primary juvenile period: Less than 1 year (P. Kubiak pers. comm.).
Flowers: White or pale pink, September–February, peak November. Probably pollinated mainly by honeybees, flies (P. Kubiak pers. comm.).
Fruit/seed: Capsule.
Dispersal, establishment & growth:
Fire response: Possibly killed after high intensity fire (1/94) at Lane Cove (P. Kubiak pers. comm.).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC CC SC; Qld, Vic., Tas., S.A., W.A., N.Z., Pac., S Amer.
Distribution Sydney area: Coastal.
Select locations: CC: Avoca,Toukley, Barrenjoey, Narrabeen, Middle Harbour Creek (L.McD.), Bobbin Head, Parramatta, Cooks River, Garie Beach, Austinmer, Shellharbour.

Habitat

Habitat: Waterlogged places (Romanowski 1998), margins of brackish or salty coastal streams, coastal headlands.
Altitude: 0–20 m **Annual rainfall:** 1200–1400 mm
Typical local abundance:
Vegetation: Saltmarsh e.g. with *Juncus kraussii, Baumea juncea, Sarcocornia quinqueflora*; swamp margins e.g. with *Melaleuca quinquenervia, Casuarina glauca*; cliffline vegetation e.g. with *Zoysia pungens, Apium prostratum.*
Substrate: Muddy sand, or skeletal sandy soil on sandstone, conglomerate, basalt. Saline soils and waters (Romanowski 1998).
Exposure:

Conservation

Conservation: Conservation status unknown.

Samolus valerandi PRIMULACEAE

Common Brookweed, Water Pimpernel

Life history

Growth form: Herb with weakly erect stems 10–30 cm high, stoloniferous. Leaves thin, almost transluscent and over 1 cm across (Romanowski 1998).
Vegetative spread: Possibly spread by stolons.
Longevity:
Primary juvenile period:
Flowers: White, October–March, peak March.
Fruit/seed: Capsule.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC CC SC NT CT ST ; Qld, Vic., S.A., W.A., Eur, N & S Amer, Afr.
Distribution Sydney area: Mainly western Sydney.
Select locations: CC: Colo River, Kellyville, Berkshire Park, Nortons Basin, Warwick Farm, Casula, Douglas Park, Kowmung River. **CT:** Fremantle, Abercromie.

Habitat

Habitat: Moist, shady creekbanks.
Altitude: 0–800 m **Annual rainfall:** 600–800 mm
Typical local abundance: Frequent–occasional.
Vegetation: Riverine forest e.g. with *Casuarina cunninghamiana, Tristaniopsis laurina, Angophora floribunda* and ground species such as *Triglochin procera, Potamogeton ochratus, Lilaeopsis polyantha, Sparganium subglobosum.*
Substrate: Sandy to muddy alluvium, medium nutrients.
Exposure:

Conservation

Conservation: Mainly found along creeks in western Sydney and vulnerable to increasing degradation and weed invasion. Listed vulnerable in Western Sydney (James et al. 1999). Conservation status elsewhere unknown.

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Scientific names are in bold type and family names are in upper case. Common names are in roman type. Exotic species are indicated by an asterisk following the botanical name.

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New

Missing Jigsaw Pieces:

The Bushplants of the Cooks River Valley

by Doug Benson, Danie Ondinea and Virginia Bear

Through photographs, original drawings, and a lively text **Missing Jigsaw Pieces** presents a broad perspective of the natural landscape of the Cooks River Valley Despite the degradation of the last 200 years, the valley still contains much that is natural and of intrinsic value. These remnants are the jigsaw pieces which allow us to piece together the story of the bushland valley.

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Vegetation Survey of the Barrington Tops and Mount Royal National Parks for use in Fire Management

Toivo Zoete

Zoete, T. (ERM, 24 Falcon Street, Crows Nest NSW 2065 Australia) 2000. Vegetation Survey of the Barrington Tops and Mount Royal National Parks for use in Fire Management. Cunninghamia *6(3): 511–578.* This paper reports on a vegetation study undertaken to enable the development of appropriate fire management strategies for the conservation of biodiversity. The approach taken is to relate fire response mechanisms reported for species within the literature to floristic patterns.

Floristic and environmental data were obtained from the National Parks and Wildlife Service. The data set was derived from 262 plots located within and around the study area. Data were analysed using classification, ordination, one way non-parametric analysis of variance, and correlation routines contained within the PATN computer package.

On the basis of this analysis, 14 Vegetation Communities were delineated including 12 non-rainforest communities. There was a strong relationship between the floristic pattern and a number of environmental variables, including altitude, climatic variables, geographic location, and geology. 'Years Since Logging' and 'Years Since Last Fire' were also relatively highly correlated, but much of this data is based on subjective field estimates in relatively few sites, often several years after a fire had occurred and is therefore less reliable.

The relationships between floristic data and known plant fire response mechanisms, were generally weak, though significant. The weakness of the correlation is probably due to the lack of information on fire response for many species. On the basis of the existing data base, preliminary guidelines are provided on the nature of suitable fire regimes. Suggestions are given for further study of the floristic pattern, fire history, and other data required to guide ecological fire management in the future.

Introduction

This vegetation study was conducted to provide information to the National Parks and Wildlife Service (NPWS) for the development of appropriate fire management strategies for the conservation of biodiversity within the Barrington Tops and Mount Royal National Parks. The study area for this project encompasses all of the two National Parks as well as areas adjacent to these Parks for which data were available. Emphasis was on the fire adapted vegetation (i.e. non-rainforest vegetation).

The overall approach taken was to relate fire response mechanisms reported for species within the literature (summarised in the National Plant Fire Response Register — Gill & Bradstock 1992) to floristic patterns.

Study area

The Barrington Tops and Mount Royal National Parks cover an area of approximately 67 530 ha, and are located about 100 km north-west of Newcastle, between the towns of Scone and Gloucester (Fig. 1). The Parks are oriented around two plateaux, including the Barrington Tops and the Gloucester Tops plateaux. Together they occupy the southern end of the Mount Royal Range, which runs from the Great Escarpment and the Liverpool Range towards the south-east. The Tops separate the valleys of the upper Hunter River and its tributaries from the valleys of the Manning River. Altitudes vary from less than 200 m asl in the south-eastern part of Barrington Tops National Park to over 1500 m asl on the main plateau in the northern section of that Park.

Considerable climatic variation exists within the study area, concordant with the rugged topography (CMPS&F 1995). Climate ranges from cool temperate conditions at higher altitudes to warm temperate conditions at lower altitudes. The climate is generally sub-humid, although rainfall varies with altitude and longitude. Areas on the lower slopes are generally drier, with mean annual rainfalls of approximately 1000 mm, while areas in the rain shadow of the plateau further inland are driest with a mean annual rainfall of less than 700 mm. On the other hand, areas over 700 m elevation experience a mean annual precipitation of up to 2000 mm. Much of the precipitation at higher elevations is in the form of heavy moist fogs or snowfalls

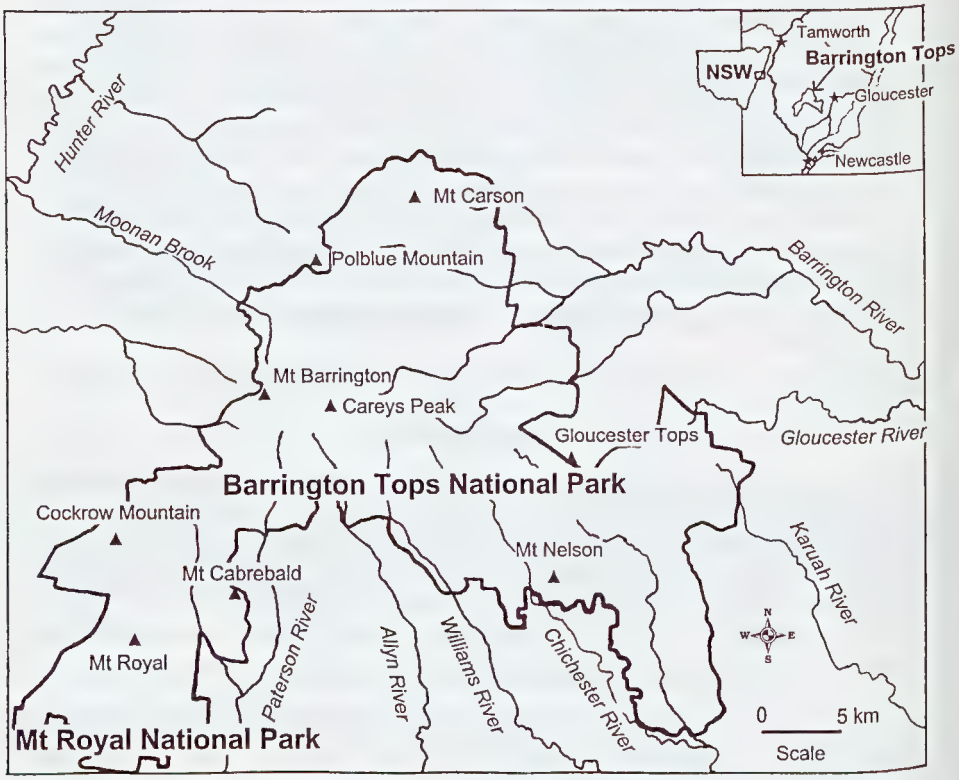

Fig. 1. The study area.

during winter. Up to five snowfalls occur at elevations over 1100 m asl, although most falls are light (10–20 cm depth). Freak snowfalls occur down to 300 m asl approximately once per five years. Rainfall is greatest during the warmer summer months, while late autumn and spring are the driest seasons. Temperatures in surrounding lowland vary from a mean maximum of approximately 23–24°C to a mean minimum of approximately 10–11°C. At higher elevations, temperatures are 5–7 degrees lower than in the valleys, with a minimum of -17°C recorded at 1500 m asl.

Winds tend from the west during July, August and September. Coupled with low rainfall, these winds can provide fire danger conditions in late winter and spring. During October to December winds tend further from the north, resulting in warmer temperatures. If below average rainfalls are experienced during these periods, extreme fire danger conditions can develop. Close to the escarpment, mountain winds (föhn) have a pronounced influence on the behaviour of fire due to their high velocity. Generally, the higher areas of the study area are low fire risks due to the extended cool and moist conditions experienced here (C. Howard, pers. comm.). At lower altitudes, moist conditions in rainforest areas provide barriers to the spread of fire. Generally, fire travels only along the drier ridge lines at lower altitudes, due to moister conditions on the slopes and valleys below.

Three parent rock types with corresponding soil types are found within the boundaries of the study area (Veness & Associates 1995). The oldest rocks date from the Carboniferous Period and consist of an undifferentiated mixture of fine-grained quartz-poor lithic sandstone, conglomerate, siltstone, mudstone, and pyroclastics. This type of rock underlies most of the lower slopes of the study area. Soils developed on these rocks contain friable, usually stony surfaces with abundant organic materials. Both top-soils and sub-soils are generally stony and pedal. Acidity varies from weak to moderate in the top-soil to weak to strong in the sub-soil. Soil depth ranges from 19 cm to over 120 cm.

Granodiorite intruded the landscape in the Middle Permian Period, and presently remain in the Barrington tops area. Soils developed on granodiorite are friable with scattered granodiorite stones. Top-soils are weakly to moderately acid, but sub-soils are moderately to strongly acid. Soil depth varies from 58 cm to over 130 cm.

Intense volcanic activity during the Tertiary resulted in lava flow which settled in the valleys and formed protective caps for the underlying (Carboniferous) sediments. Extensive weathering has since eroded the surrounding hills, resulting in an inverse landscape with the volcanic basalt rocks presently remaining in the highest parts of the plateaux. Soils developed on Tertiary basalt are friable, strongly pedal, and contain organic material and stones. Top-soils are weakly acid and sub-soils are moderately to strongly acid. Soil depth varies from 72 cm to over 100 cm.

Previous flora studies in the study area

The vegetation of the Barrington Tops plateau has been the subject of numerous plant collecting excursions since the early twentieth century. Detailed study of the area commenced around 1915 (Adam 1987). However, it was not until 1937 that Fraser and

Vickery began publishing the first and, so far, only comprehensive published description of the vegetation of the plateau (Fraser & Vickery 1937, 1938, 1939). Other, unpublished, accounts of the vegetation on plateau proper include the study of Mort (1983) on sub-alpine wetland vegetation and Waterhouse (1986, 1988) on broom *(Cytisus scoparius)* infestations. A more recent study of the rare and threatened flora on the plateau is provided by Heinrich and Dowling (1998).

Other surveys and descriptions have primarily focussed on rainforest habitats, which together occupy approximately 25 000 ha (37%) of the study area. Such studies include Turner (1976), Bowden and Turner (1976) and Floyd (1983).

One prominent theme in these studies has been the advance and retreat of the *Nothofagus moorei* dominated forests. Fraser & Vickery (1938) noted that *Nothofagus moorei* dominated forests were advancing into *Eucalyptus* spp. forests at all fronts, but that they lost ground to other rainforest types at lower altitudes. The latter observation was confirmed by Turner (1976) who noted that regeneration of *Nothofagus moorei* under the *Nothofagus moorei*-warm temperate rainforest ecotone did not occur. Floyd (1983) discussed these observations at some length with additional evidence of his own field studies of the existing vegetation. Although his studies showed that there is a clear and ongoing change of vegetation, with one-way boundary shifts of up to an estimated 500 years of age, Floyd was ambivalent about the longer term implications in the absence of further long term evidence.

Such long term evidence was provided for the vegetation on the plateaux several years later through several pollen analyses from the sub-alpine wetlands found on the plateaux. These include papers by Dodson et al. (1986), Dodson and Myers (1986), Dodson et al. (1994), and Sweller and Martin (1997). Results indicate that most present day vegetation communities have been present within the area for over 9000 years, although their relative proportions have changed considerably since then (Dodson et al. 1986). An expansion of wetlands as well as forests dominated by *Nothofagus moorei* (particularly towards the north-west), which commenced approximately 6000 BP is thought to be due to an increase in rainfall and possibly temperature (Dodson et al. 1986, Sweller & Martin 1997).

The State Forest Commission of NSW (now State Forests of NSW) has previously mapped the dominant species (and some structural information) of the canopy vegetation of large parts of the study area. This mapping is known as the 'Royal Milli Forestry Maps', and a compilation of this mapping ('Royal Milli Vegetation Management Mapping') was prepared for the NPWS by McKimmie Jamieson & Partners (Aust.) Pty Ltd (1985).

A floristic analysis of the State Forests of the area, parts of which are now included within the National Park boundaries, is provided by Binns (1995).

Fire responses and the National Plant Fire Response Register

Knowledge of the vegetation response to fire can be employed to determine appropriate fire regimes for the maintenance of the current species composition and structure or to cause a shift in these characteristics, optionally to a predetermined goal.

As fire is an important and often recurring factor in many Australian ecosystems, considerable research has been conducted to qualify and quantify responses within individual species and within vegetation types (e.g. Gill & Bradstock 1992, Bradstock et al. 1995, DEST 1996). The application of this research to the management of the current study area is two-fold:

- To manage different types of vegetation;
- To manage individual species, such as significant species.

The response of vegetation to fire can be described in several ways (Gill & Bradstock 1992):

- Mechanistic descriptions, resulting in classifications of species with similar means of resistance and recovery, such as physical resistance properties of plants to fire (e.g. bark);
- Consequential descriptions, which are concerned with the end result of fire, such as survival or death;
- Strategic descriptions, which place importance on the evolutionary behaviour of species, such as whether plants are fire evaders, fire resisters, or fire endurers.

The National Plant Fire Response Register was established to provide information on each of these aspects of (Gill & Bradstock 1992). Information within the Register is sourced from the published literature, personal communications, personal observations and surveys. The 1997 version of the Register contained information on 2528 species, derived from 45 references. Fire response information is given in the form of 11 nominal categories. These are shown in Table 1.

Table 1. Codes for species' regenerative mechanisms (Source: Gill & Bradstock 1992).

Code	Mechanism
0	Unknown
1	100% scorch kills, regeneration from on-plant viable seed storage
2	100% scorch kills, regeneration from in-soil viable seed storage
3	100% scorch kills, no seed storage in burnt area
4	Survive 100% scorch, root suckers
5	Survive 100% scorch, basal sprouts
6	Survive 100% scorch, epicormics
7	Survive 100% scorch, outgrowth of large apical bud
8	1, 2, or 3 but which is unknown, and includes obligate seed regeneration of McMahon (1987)
9	4, 5, 6, or 7 but which is unknown, and includes facultative resprouters of McMahon (1987)
10	Ferns
11	Obligate resprouters of McMahon (1987)

Those species which are killed by fires and which rely on seed (in seed banks, on plant, or import of propagules from outside the burnt area) would be favoured if fires were sufficiently intense to also kill competing plants which rely primarily on their resprouting capacity for post-fire recovery (Adams & Simmons 1996). In contrast, if fires were relatively cool but frequent, seeders would be disadvantaged, as fragile seeder plant seedlings are destroyed before they can set seed.

Knowledge of the fire response of species which comprise a vegetation community can therefore be used to maintain, promote or suppress particular species or groups of species, and relatively simple deterministic fire regimes can be designed for individual species or small groups of similar species on this basis.

Problems arise when both resprouters and seeders are targeted for maintenance or promotion, as for example in a vegetation community largely consisting of resprouters, but also containing rare seeder plants and vice versa. There are also conflicts when the fire regime is based on requirements of overstorey species only, to the potential detriment of the understorey species (Keith & Bradstock 1994). In addition, desirable outcomes are also dependent on variables such as the size and shape of the area burned, unplanned fires, climatic and seasonal factors, the nature of the seedbank and soil in which it resides, interaction with non-target species, longevity of plants and propagules, age to maturity, fuel load, and regional differences in plant response mechanisms (e.g. Gill et al. 1981, Bradstock et al. 1995, DEST 1996). Data on many of these variables are lacking for most regions (Gill & Bradstock 1995), including the Barrington Tops region. Given the stochasticity of some of these variables (e.g. unplanned fires) it is also doubtful that data will ever be sufficient to design deterministic fire regimes suitable at the landscape scale over the long run.

In order to avoid some of these conflicts, and to precaution against errors made in determining fire intensities and intervals, a number of authors have emphasised the importance of fire regime variability in both space and time (Fox 1983, Lamont et al. 1993, Bradstock et al. 1995, Gill 1996). Bradstock et al. (1995) proposed the concept of a threshold level above which fire regime variability is sufficiently high to conserve full diversity (prevent the extinction of species) and below which diversity declines through fire regime uniformity. Using a model, Keith and Bradstock (1994) provided an example of how the threshold concept can be applied to a heath mosaic in the Royal National Park in which species were classified into a small number of functional groups. Input information used included the types of propagules, post-fire growth, reproductive timing, reproductive mechanism, and the competitive status.

Clearly, much of this information is not available for the vegetation of the Barrington Tops area at this stage. A considerable amount of monitoring will be required in order to generate the data required to develop models such as that by Keith and Bradstock (1994).

The emphasis of the present paper is, therefore, on the provision of floristic information, which, once further information on parameters such as those used by Keith and Bradstock (1994) becomes available, can be used to develop scientific fire regimes and relatively detailed strategies at a later stage. Nevertheless, it is considered that current information available on the regenerative mechanisms could be used as a

rudimentary guide to the formulation of interim fire management strategies, using the principles as outlined above. Monitoring should be an integral part of fire management strategy (Gill & Nicholls 1989), and, hence, guidelines for the establishment of a monitoring program are also provided.

Methods

Data sources and quality

Data on the vegetation of the study area were obtained from a variety of sources and includes plot data from within and surrounding the study area. Most data originate from plots used for the Flora Survey component (Binns 1995) of the Gloucester and Chichester Management Areas Environmental Impact Statement (EIS) (SFNSW 1995). Most of these plots were surveyed in 1991–1992 specifically for the preparation of the EIS (Binns 1995). However, a number of plots were surveyed in 1987–1989 (Binns, unpublished data), and several of these occur within the Whispering Gully part of the present study area.

Plot data from Mount Royal National Park and adjacent areas originate from such sources as the Comprehensive Resource Assessment surveys (post 1995), the North-East Biodiversity Study (1992–1993), but also includes data from older sources, possibly as old as the 1960s (P. Lezaich, State Forests NSW, pers. comm.).

A survey of a further 51 plots within the study area was commissioned by the NPWS specifically for the present project (Horton & Hunter, unpublished data). These plots are mostly located in the central and south-eastern parts of the Barrington Tops National Park.

All data was supplied by NPWS Northern Zone Office. The total number of plots used in the analyses for this project was 262, of which 154 plots were located within the boundaries of the National Parks.

Information obtained from each plot included a list of plant species present and their abundances as expressed in a code based on a modified Braun-Blanquet scale for cover (Table 2).

Table 2. Modified Braun-Blanquet scale for plant species' canopy cover.

Cover Code	Projected Canopy Cover
1	< 5%, few individuals
2	< 5%, any number of individuals
3	6–25%
4	26–50%
5	51–75%
6	75–100%

The availability and consistency of other information, such as structural and environmental data, varied considerably from plot to plot. Some of these data were estimates that may differ from observer to observer. This data was, therefore, sometimes of limited use in the analysis for the present project. Nevertheless, even though some estimates may have been somewhat coarse, data utilised for analyses included data on estimated severity and frequency of fires and past logging, altitude, aspect, slope, landform element, morphology, soil group, and soil depth. Such data was available for 15–120 plots, depending on the variable.

Other environmental information used include data from the NPWS Coffs Harbour Northern Zone office GIS system. This information includes data on climate, terrain, and geology. Data for these variables was available for all plots.

Lists of rare and threatened species and exotic species were obtained from the NPWS Coffs Harbour Northern Zone office. Plant responses to fire were sourced from the National Plant Fire-Response Register held by the Malcolm Gill (CSIRO).

Analysis

Floristic data were analysed using a number of routines provided within the PATN computer package (Belbin 1993). In order to restore the approximate cover ratios encountered in the field, the cover codes supplied in the original data were transformed to the midpoints of the percentage cover intervals represented by the codes, except for code intervals 1 and 2, which were transformed to 1% and 3%, respectively.

Information on the structural characteristics of the vegetation was patchy, preventing the differential weighting of canopy species and understorey species. All species were therefore treated equally within the analyses. Although this introduces distortions with respect to the reflection of the ecological significance of species found in different vegetation strata within the covariance matrix (see below), it should be noted that the emphasis of the current project is on the understorey vegetation of the study area, as this is the vegetation stratum which is of greatest significance for fire management. The dominant influence of the species rich lower strata within the analyses applied is therefore justified.

Data of many environmental variables were originally in a nominal (non-numerical) format. For example, 'values' for variables such as morphology and geology included 'tertiary basalt' and 'hill slope'. Because most of the analyses conducted require ratio type data, nominal variables were converted to binary (presence-absence) variables, resulting in one extra variable for each nominal value. A total number of 54 environmental variables were thus used in the analysis. These are listed in Table 3.

A similar treatment was conducted for data obtained from the National Plant Fire Response Register. As the register is based on 45 literature references from different authors, species are frequently listed with a number of fire response mechanisms, as different authors have observed different mechanisms. To facilitate analysis and data management, only the first (often the only) mechanism observed was used.

Table 3. Environmental variables used in the analysis.

GIS variables

Description	Type
Longitude (AMG)	Ratio
Latitude (AMG)	Ratio
Minimum temperature at the coldest month (°C ×10)	Ratio
Mean annual temperature (°C ×10)	Ratio
Solar radiation (MJm^{-2} day^{-1}	Ratio
Soil fertility (from soil landscape maps, geochemical data modelling)	Interval
Slope (degrees)	Ratio
Soil depth (mm)	Ratio
Mean annual rainfall (mm)	Ratio
Wetness or compound topographic index (derived from terrain variables)	Ratio
Skidmore topographic position — mean difference in elevation	Ratio
Ruggedness index (250 m window)	Ratio
Ruggedness index (500 m window)	Ratio
Ruggedness index (1000 m window)	Ratio
Topographic index (250 m window)	Ratio
Topographic index (500 m window)	Ratio
Topographic index (1000 m window)	Ratio
NEFBS moisture index (from other GIS information)	Ratio
Rainfall in the driest quarter of the year (mm)	Ratio
DLWC geology map units	Nominal
Basic igneous	Binary
Acidic volcanic	Binary
Granite	Binary
Sedimentary rocks (high quartz)	Binary
Sedimentary rocks (low quartz)	Binary

Plot variables

Description	Type
Field estimate of previous fire severity (0–3)	Interval
Estimate or record of years since last fire	Ratio
Altitude (m)	Ratio
Slope (degrees)	Ratio
Aspect (degrees)	Ratio
Landform Element	Nominal
Bench	Binary
Drainage depression	Binary
Foot slope	Binary
Gully	Binary
Hill crest	Binary
Hill slope	Binary
Scarp	Binary
Stream channel	Binary
Swamp	Binary
Valley flat	Binary

Morphology	Nominal
Crest	Binary
Closed depression	Binary
Flat	Binary
Lower slope	Binary
Mid-slope	Binary
Simple slope	Binary
Upper slope	Binary
Open depression	Binary
Soil Type	Nominal
Clay	Binary
Loam	Binary
Sand	Binary
Organic	Binary
Soil depth (in three classes)	Interval
Field estimate of previous logging severity (0–3)	Interval
Estimate or record of years since last logging	Ratio
Field estimate of previous grazing severity (0–3)	Interval
Estimate or record of years since last grazing	Ratio

While this may have introduced some bias, most mechanisms listed for a species were closely related. In order to cancel out some bias, related mechanisms were also amalgamated into two contrasting groups, including one group with species relying on seed regeneration, and another with species relying more on resprouting. All regenerative mechanisms were converted to binary variables

In this paper, it is assumed that species with higher abundance require greater emphasis than less abundant species when the objective is to maintain the species composition of vegetation. 'Present' values (i.e. '1') were, therefore, subsequently weighted by the transformed percentage cover data for each matching species to increase the importance of abundant species. Only native species were used for the fire response analyses.

Gross variables were created by amalgamating all seeder mechanisms and all resprouter mechanisms into two contrasting groups, including one group ('Seeder') with mechanisms 1, 2, 3, and 8, and the other ('Resprouter') with mechanisms 4, 5, 6, 7, 9 and 11 (see Table 1). Mechanism 10 ('Ferns') was not reclassified in this manner, as the affinity of this group of plant for either of the two gross variables is not clear or varies. To eliminate the effect of different species numbers among sites and vegetation communities, a variable 'Resprouter:Seeder' was created by dividing the number of species with the 'Seeder' variable with the number of species with the 'Resprouter' variable. Missing data were coded as -9999.

The Bray and Curtis dissimilarity measure was used as a measure of the differences between the floristic composition of the plots. It has consistently performed well in a variety of tests and simulations on different types of data (Faith et al.1987). The plots were classified using the flexible unweighted pair-groups method using arithmetic averages (UPGMA) (a hierarchical agglomorative procedure), with a default beta

value of -0.1. The number of vegetation communities to be used for subsequent mapping and further analysis was initially determined by taking the root of the total number of plots used for the analysis, thus resulting in 16 communities. However, detailed examination of the 16 communities indicated that two of these communities were not meaningfully different from adjacent communities (Binns, pers. comm.), hence the final group definition level chosen was 14.

A non-parametric one-way Analysis of Variance (ANOVA) was used to determine the importance of individual species, environmental variables, and fire response mechanisms in discriminating between the vegetation communities. The technique yields the Kruskal-Wallis statistic. Within any data set, variables with higher Kruskal-Wallis value are more significant that those with lower values.

The plots were also ordinated, using the detrended correspondence analysis technique (DCA) (Hill & Gauch 1980). This technique allocates most of the variation within the data set into the first dimension, with less variation in each subsequent dimension. Environmental and fire response variables were correlated to the first four (most important) dimensions of the ordination space using the principal axis correlation facility provided in PATN. The significance level of the correlation was approximated with Monte Carlo methods.

Results

Species recorded

A total of 890 species (including 66 species identified to genus level only) were found within the 262 plots, representing a total of 11 538 records. Records do not include plant species found outside the plots. The total number of species is therefore likely to be an underestimate of the true number of species present. In addition, plants such as members of the Orchidaceae and Liliaceae may have been overlooked during plot surveys if surveys were conducted outside growing seasons, further reducing the proportion of plants sampled. Appendix A contains a listing for all species found.

Eight rare or threatened plant species were recorded in the plots surveyed for this project, in 60 records. Half the records (30) were from outside the National Park boundaries, including all records of *Grevillea granulifera*. Only seven species were recorded from within the Park boundaries. Several other rare or threatened plants are also known from the area, or have ranges which overlap the study area. Table 4 contains a list of species found within the area and their conservation status, based on Binns (1995), Heinrich and Dowling (1998) and R. Onfray (NPWS, pers. comm.).

An unusual record is that of *Eucalyptus macrorhyncha* found in some plots in the Stewarts Brook area. This species has not previously been encountered in the area. Samples have, however, been identified as belonging to *Eucalyptus macrorhyncha* by the herbarium of the Royal Botanic Gardens, though the features of the samples were somewhat atypical (Binns, pers. comm.).

Table 4. Rare or threatened plants within data set and their conservation status.

Species Name	Authority	ROTAP*	TSC
Acacia barringtonensis	Tind.	3RCa	
Asperula asthenes	Airy Shaw & Turrill	3VC-	Vulnerable
Chiloglottis palachila	D.L.Jones	3RC-	
Chiloglottis platyptera	D.L.Jones	2KC-	
Chiloglottis sp. aff. *pluricallata*			
Chiloglottis sphyrnoides	D.L.Jones	3KC-	
Chionogentias barringtonensis	L.G.Adams	2RC-	
Corybas sp. A		2RC-	
Cynanchum elegans	(Benth.) Domin	3ECi	
Diuris venosa	Rupp	2VC-	Vulnerable
Eucalyptus largeana	Blakely & Beuzev.	3R	
Euphrasia ciliolata	W.R.Barker	2KC-	
Galium curvihirtum	Ehrend. & McGillivray		
Grevillea granulifera	(McGillivray) R.Olde & N.Marriott	3KCa	
Hibbertia hermanniifolia	DC.	3RC-	
Leptospermum argenteum	J.Thompson	2RC-	
Leucopogon pilifer	Wakef.		
Marsdenia liisae	J.Williams	3 RC-	
Microtis sp. aff. *rara*	suggested by D.L.Jones		
Orthoceras strictum forma virile	suggested by D.L.Jones		
Ozothmanus sp. 1		2KC-t	
Phebalium sp.			
Plantago cladarophylla	B.G.Briggs, Carolin & Pulley	2RC-	
Plantago palustris	L.Fraser & Vick.	2RC-	
Plectranthus suaveolens	S.T.Blake	3KC-	
Pomaderris helianthemifolia	(Reisseck) Wakef.		
Prasophyllum rogersii	suggested by D.L.Jones		
Prasophyllum sp. A			
Prasophyllum sp. aff. *fuscum*	suggested by D.L.Jones		
Prasophyllum sp. aff. *odoratum*	suggested by D.L.Jones		
Pterostylis cucullata (sp. D)	R.Br.	3VCa	Vulnerable
Pterostylis elegans	suggested by D.L.Jones		
Pterostylis falcata (sp.C)	R.S.Rogers		
Pterostylis sp. aff. *cycnocephala*	suggested by D.L.Jones		
Pterostylis sp. aff. *parviflora*			
Senecio macranthus		3RC-	
Senna acclinis	(F.Muell.) Randell	3 RC-	
Tasmannia glaucifolia	J.Williams	3VCi	Vulnerable
Tasmannian purpurascens	(Vick.) A.C.Smith	2VC-t	Vulnerable

* 2: Restricted distribution in Australia (range < 100 km); 3: Range >100 km in Australia but in small, restricted populations;

E: Endangered; V: Vulnerable; R: Rare; K: Poorly known; C: Represented in national park or proclaimed reserve; a: adequately reserved; i: inadequately reserved; -: insufficient data; t: total known population reserved (see Briggs & Leigh 1995).

The incidence of exotic plants was generally low, with most species occurring at less than 5% cover at any plot where present. One exotic species with considerably stronger presence was *Cytisus scoparius*, which dominated the vegetation in some plots on the Barrington Tops plateau. It is one of the characteristic species of Vegetation Community 10, occurring around the edges of the sub-alpine wetlands (see Appendix B). It was introduced into the area in the 1840s, though it was not until the 1950's and 1960's that the species build up to nuisance levels (Waterhouse 1988). With the dedication of the southern end of the plateau as a National Park in 1969, seasonal cattle grazing and burning ceased, resulting in further expansion. By 1988, 10 000 ha were affected by *Cytisus scoparius*, with native undergrowth and overstorey species regrowth affected through shading by *Cytisus scoparius* (Waterhouse 1988). Since then the area affected has been successfully contained using chemical agents and some hand removal for control, though the density within the infestation increased (M. Schroeder pers. comm.).

In order to open up smaller areas known to be populated by rare or threatened plants, *Cytisus scoparius* is removed by hand. It is hoped that biological control agents, released since 1993, will be able to reduce the density across the larger infestation. However, considerable lead time will be required (up to 20 years) before these agents are anticipated to cause an impact (M. Schroeder pers. comm.). Further containment will therefore be necessary.

Another exotic species occurring in a much larger area than *Cytisus scoparius* is *Conyza albida*. It is common in the Mount Royal area as well as in the northern parts of the plateau, but generally occurs at relatively low quantities. No information is available on the history of this species within the study area. It is, however, unlikely that the species will develop into a problem weed, such as Broom, as it is typically a species of disturbed sites only. Most of the remaining exotic species are also typical of disturbed sites, and have a preference for moist conditions, such as gullies, riparian zones, and swamps.

Classification

As noted above, a total of 14 communities were delineated. An abbreviated dendrogram of the UPGMA classification showing the hierarchical arrangement of the 14 vegetation communities is shown in Fig. 2. Appendix B provides vegetation community profiles, detailing species with the highest fidelity (i.e. Kruskal-Wallis statistics), highest mean cover, and highest constancy. Tables 5 and 6 show the values and Kruskal-Wallis statistics respectively of the environmental characteristics of each community. The geographic distribution is shown in Fig. 3.

In brief, the results indicate that Community 1 to 6 represent *Eucalyptus* species dominated forest with species typical of the drier, lower slopes, with Community 3 and 5 at the wetter end of the spectrum and located primarily along clearly defined watercourses. Community 4 is a shrubby type vegetation (occasionally with trees), typical of rocky outcrops throughout the study area (Binns, pers. comm.), although some species found within the plots comprising this vegetation community occur only in areas adjacent to the National Park boundaries (e.g. *Grevillea granulifera* and *Eucalyptus macrorhyncha*).

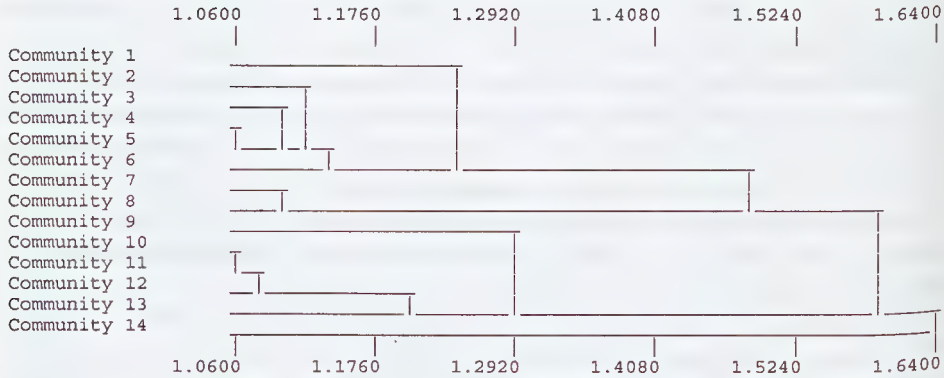

Fig. 2. Abbreviated dendrogram hierachical arrangement of vegetation communities. The relative dissimilarity values are shown alongside the dendrogram.

of 8.918, 6.181, 4.763, and 4.719. This indicates that there is at least one complete species turnover along each of these axes, with two turnovers in the first dimension. Thus, the species composition on the one end of the axis is completely different from that on the other end of the axis, with two such cycles in the first dimension (i.e. the first axis shows most of the variation).

Principal axis correlations for environmental variables are also listed in Table 6. Figs 4 and 5 show the vectors (standard length = 1) for variables with correlations over 0.5 and $p < 0.01$ in relation to the distribution of the plots in the first three dimensions of the species space.

Fig. 4 shows that the major floristic gradient (dimension 1) in the vegetation is from sub-alpine swamp (Community 12) and montane *Eucalyptus* spp. dominated vegetation types (Community 9 to 11) to rainforest (Community 7) and wet sclerophyll forest (Community 8). Another important gradient (dimension 2) is from the *Nothofagus moorei* dominated forests to the drier *Eucalyptus* spp. forests. Both floristic gradients appear to be related to changes in altitude, rainfall, temperature, and latitude, while time since last fire is particularly correlated with the second dimension.

The third floristic gradient is less clear but highlights the distinctiveness of some riparian vegetation types (Communities 5 and 11) at one extreme (Fig. 5). This pattern appears to be correlated to geology, soil fertility, and longitude.

Correlations with fire response mechanisms were weak but mostly significant (Table 8). The only mechanism which was insignificant was mechanism 11 (obligate resprouters). Only three mechanism had correlations over 0.5 ('resprouters', and mechanisms 4 and 5).

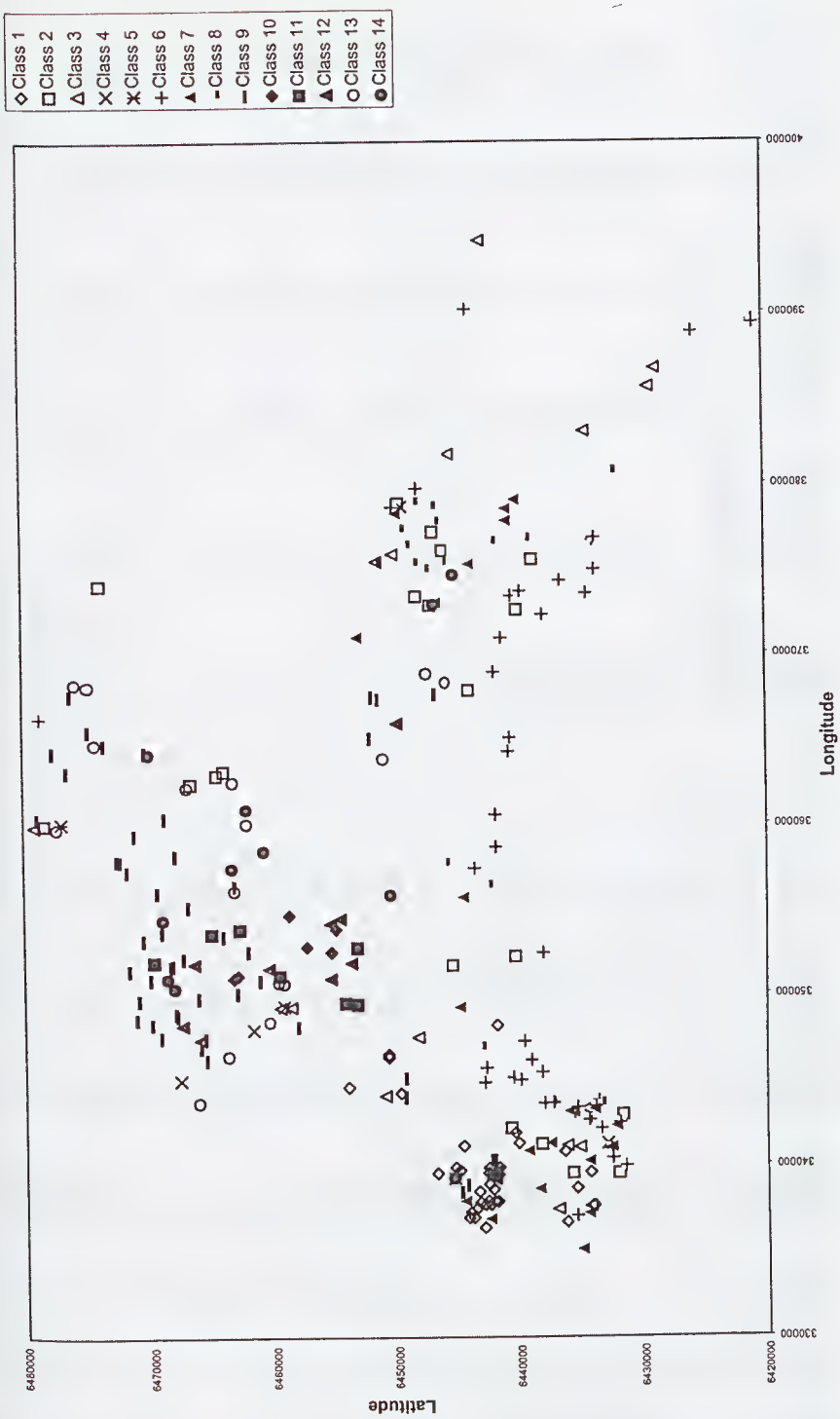

Fig. 3. Diagram showing the distribution of vegetation classes among plots in geographical space.

Table 5. Environmental values of vegeatation communities (the 15 variables with the highest Kruskal-Wallis values are shown only).

Community		Min. temp. (°C)	Mean temp. (°C)	Annual rainfall (mm)	Rainfall in driest quarter (mm)	Moisture index (mm)	Soil depth	Soil fertility	Basic igneous (index) (0=absent 1=present)	Low quartz sedimentary rock (0=absent 1=present)	Rugged-ness rock	Rugged-ness (250m)	Rugged-ness (500m)	Altitude (mm) (1000m)
1	Min.	-1.9	9.9	1172	228	81	959	2	0	0	9	17	35	850
	Max.	1.5	15.1	1852	396	94	1100	5	1	1	55	70	111	850
	Mean	-1.3	12.5	1415	291	90	1028	3.6	0.6	0.4	20.1	36	63.9	850
2	Min.	-2.1	11.6	1038	168	79	920	2	0	0	8	18	47	500
	Max.	2.1	15.2	1852	372	94	1070	5	1	1	41	63	118	1080
	Mean	-0.8	12.8	1415	291	90	1001	2.5	0.2	0.8	24.4	41.7	70.5	855
3	Min.	-2.2	12	1042	162	78	959	2	0	0	7	14	26	240
	Max.	5.8	17	1680	342	94	1139	5	1	1	39	72	121	760
	Mean	0.8	14.2	1343	241	87	1048	2.2	0.1	0.6	21.1	37.4	64.5	482
4	Min.	-1.3	11.2	1168	210	83	819	2	0	0	24	43	75	630
	Max.	1.3	14.9	1500	312	95	1009	2	0	1	41	77	134	1130
	Mean	-0.3	12.7	1376	266	89	952	2	0	0.4	31.6	51.4	91.2	880
5	Min.	-1.7	10.6	1300	270	93	970	2	0	0	8	15	29	-
	Max.	-0.6	12.1	1610	342	93	1080	4	1	1	37	70	105	-
	Mean	-1	11.3	1481	310	93	1040	3.3	0.7	0.3	20	38	70	-
6	Min.	-1.1	13.2	810	168	76	810	2	0	0	8	13	22	140
	Max.	5.6	17	1120	300	92	1120	2	0	1	61	70	94	600
	Mean	2.3	15.3	1023	218	85	1023	2	0	0.7	23.9	38.8	57.5	430
7	Min.	-1.9	12	1132	198	79	990	2	0	0	11	18	27	620
	Max.	3	15.9	1890	342	94	1129	5	1	1	31	57	113	870
	Mean	0.3	13.4	1388	250	88	1061	2.1	0.1	0.8	19.2	33.6	27.5	745

	Community temp. (°C)	Min. temp. (°C)	Mean rainfall (mm)	Annual driest quarter (mm)	Rainfall in index	Moisture depth (mm)	Soil fertility (index)	Soil igneous rock (0=absent 1=present)	Basic sedimentary rock (0=absent 1=present)	Low quartz (250m)	Ruggedness (500m)	Ruggedness (1000m)	Ruggedness (mm)	Altitude
8	Min.	-1.7	12	1156	180	81	970	2	0	0	9	14	23	400
	Max.	3.6	16.2	1872	324	93	1159	2	0	1	40	68	88	880
	Mean	3.2	14	1523	251	90	1044	2	0	0.9	24.3	41.2	63.9	675
9	Min.	-1.9	8.9	1104	222	82	939	1	0	0	1	3	8	840
	Max.	-0.6	12.8	2298	450	95	1179	5	1	1	38	55	96	1500
	Mean	-1	10.5	1565	325	93	1068	3	0.5	0.2	13.2	23.5	39.6	1258
10	Min.	-1.7	9	1844	390	94	1110	4	0	0	2	2	6	1430
	Max.	-1.3	9.4	2248	468	95	1220	4	1	0	8	16	29	1500
	Mean	-1.5	9.2	2087	440	95	1171	4	0.7	0	5.8	9.8	16.8	1452
11	Min.	-1.7	8.9	1438	306	94	1019	4	0	0	4	10	16	1310
	Max.	-1.1	9.9	2336	486	95	1190	4	1	0	16	25	68	1540
	Mean	-1.4	9.3	1983	418	94.7	1128	4	0.9	0	8	16.1	32.3	1463
12	Min.	-1.6	9	1432	312	93	1049	2	0	0	2	7	17	1200
	Max.	-0.7	10.6	2292	480	95	1190	4	1	0	12	22	24	1460
	Mean	-1.2	9.7	1959	411	95	1143	3.6	0.6	0	5.8	12.1	21.1	1377
13	Min.	-1.7	10	1238	246	91	970	2	0	0	4	10	24	1000
	Max.	-0.6	12.1	2336	468	95	1220	4	1	1	39	63	116	1380
	Mean	-0.9	11	1618	325	93	1063	2.7	0.2	0.6	20.5	35.3	61	1273
14	Min.	-1.3	9.5	1462	312	93	990	2	0	0	7	13	21	1040
	Max.	-0.6	11.8	2280	468	95	1120	4	1	1	40	69	104	1380
	Mean	-1	10.4	1761	356	94	1069	3.3	0.5	0.4	19.3	33.9	59.1	1273

Table 6. Principal axis correlations and Kruskal-Wallis statistics for environmental variables.

Variables	Correlation Coefficient (p)	Kruskal-Wallis statistic (p)
GIS variables		
Acidic volcanic	0.1256 N.S.	12.79 N.S.
Basic Igneous	0.5312 **	85.75 **
Granite	0.4172 **	53.34 **
Sedimentary rocks (high quartz)	0.3061 **	30.96 **
Sedimentary rocks (low quartz)	0.5513 **	83.43 **
Latitude	0.7455 **	151.85 **
Longitude	0.5635 **	80.86 **
Mean annual rainfall	0.5884 **	83.63 **
Mean annual temperature	0.8965 **	207.45 **
Minimum temperature at the coldest month	0.6135 **	110.43 **
NEFBS moisture index	0.7036 **	154.26 **
Rainfall in the driest quarter of the year	0.7704 **	149.33 **
Wetness index	0.2789 **	52.53 **
Solar radiation	0.3832 **	56.89 **
Ruggedness index (1000 m window)	0.3655 **	84.66 **
Ruggedness index (250 m window)	0.4353 **	91.01 **
Ruggedness index (500 m window)	0.4173 **	89.2 **
Skidmore topographic position	0.1522 N.S.	34.34 **
Slope	0.3809 **	73.86 **
Soil depth	0.3822 **	77.41 **
Soil fertility	0.5342 **	91.38 **
Topographic index (1000 m window)	0.2300 **	54.7 **
Topographic index (250 m window)	0.3229 **	19.13 N.S.
Topographic index (500 m window)	0.2844 **	35.11 **
Plot Variables		
Altitude	0.9273 **	92.90 **
Slope	0.4237 **	36.33 **
North facing	0.1158 N.S.	5.98 N.S.
North-east facing	0.2316 N.S.	12.18 N.S.
East facing	0.3562 **	10.61 N.S.
South-east facing	0.0759 N.S.	12.91 N.S.
South facing	0.2420 N.S.	15.86 N.S.
South-west facing	0.1021 N.S.	5.89 N.S.
West facing	0.2342 N.S.	10.42 N.S.
North-west facing	0.1287 N.S.	8.07 N.S.
Field estimate of previous fire severity	0.4291 *	23.07 *
Estimate or record of years since last fire	0.5617 **	33.37 **
Field estimate of previous grazing severity	0.3740 N.S.	14.79 N.S.
Estimate or record of years since last grazing	0.4510 N.S.	7.31 N.S.
Field estimate of previous logging severity	0.3740 N.S.	22.08 *
Estimate or record of time since last logging	0.6205 *	11.14 N.S.
Soil depth	0.2523 N.S.	20.39 N.S.

Variables	Correlation Coefficient (p)	Kruskal-Wallis statistic (p)
Clay	0.1368 N.S.	11.94 N.S.
Loam	0.1605 N.S.	16.94 N.S.
Sand	0.3969 **	28.22 **
Organic soil	0.2842 N.S.	20.24 N.S.
Crest	0.1567 N.S.	16.38 N.S.
Upper slope	0.1154 N.S.	12.13 N.S.
Mid-slope	0.1826 N.S.	15.00 N.S.
Lower slope	0.1924 N.S.	10.94 N.S.
Simple slope	0.3327 *	22.34 *
Flat	0.1940 N.S.	13.25 N.S.
Open depression	0.1449 N.S.	34.15 *
Closed depression	0.1213 N.S.	6.51 N.S.
Hill crest	0.1631 N.S.	16.44 N.S.
Hill slope	0.2701 N.S.	21.85 *
Bench	0.1438 N.S.	8.93 N.S.
Scarp	0.1227 N.S.	6.83 N.S.
Stream channel	0.1716 N.S.	13.25 N.S.
Swamp	0.2067 N.S.	13.25 N.S.
Valley flat	0.1940 N.S.	13.25 N.S.
Drainage depression	0.2072 N.S.	13.25 N.S.
Gully	0.2788 *	18.00 N.S.
Foot slope	0.1886 N.S.	4.72 N.S.

N.S. = $p > 0.05$; * = $p < 0.05$; ** = $p < 0.01$

Community 7 and 8 represent plots in the moister environments on the lower slopes with rainforest (without *Eucalyptus* spp.) and wet sclerophyll (with *Eucalyptus* spp.), respectively.

Community 9 to 13 consist of plots with montane and sub-alpine *Eucalyptus* spp. forest and woodland as well as wetland vegetation typical of the plateaux.

Community 14 consists of *Nothofagus moorei* dominated vegetation, and is primarily located on the sheltered escarpment slopes on the edge of the plateaux as well as in sheltered locations on the plateaux.

Table 7 lists the average number of species per vegetation community for each fire response mechanism. The total number of native species records matching with a known fire response from the National Fire Response Register was 5364. As the total number of plant records was 11 538, not all species found within the study area are therefore accounted for in the averages. Nevertheless, Kruskal-Wallis statistics were significant at $p < 0.01$ for all response mechanisms (Table 8).

Ordination

The DCA ordination of plots resulted in eigen values of 0.7979, 0.6558, 0.4155, and 0.3743 for the first four dimensions respectively, with corresponding gradient lengths

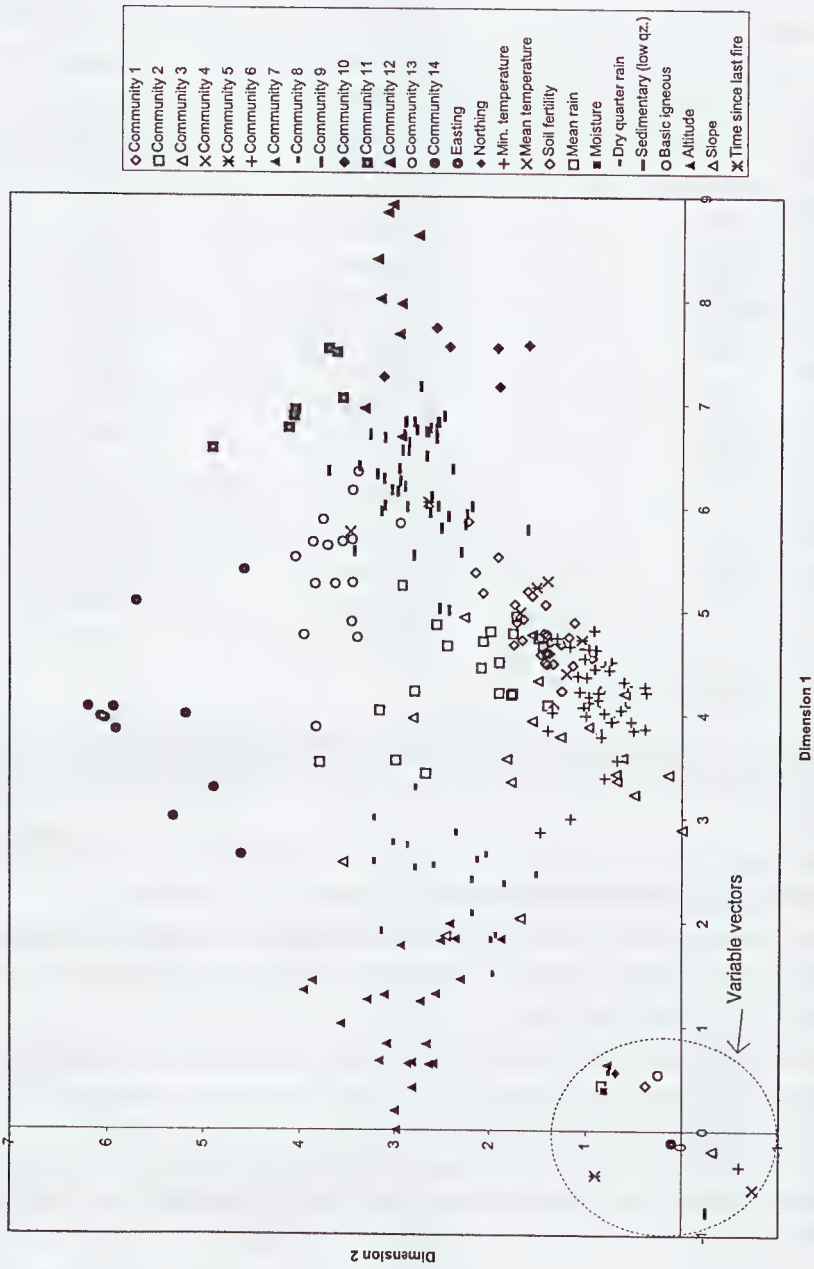

Fig. 4. Ordination of Plots (Dimensions 1 and 2).

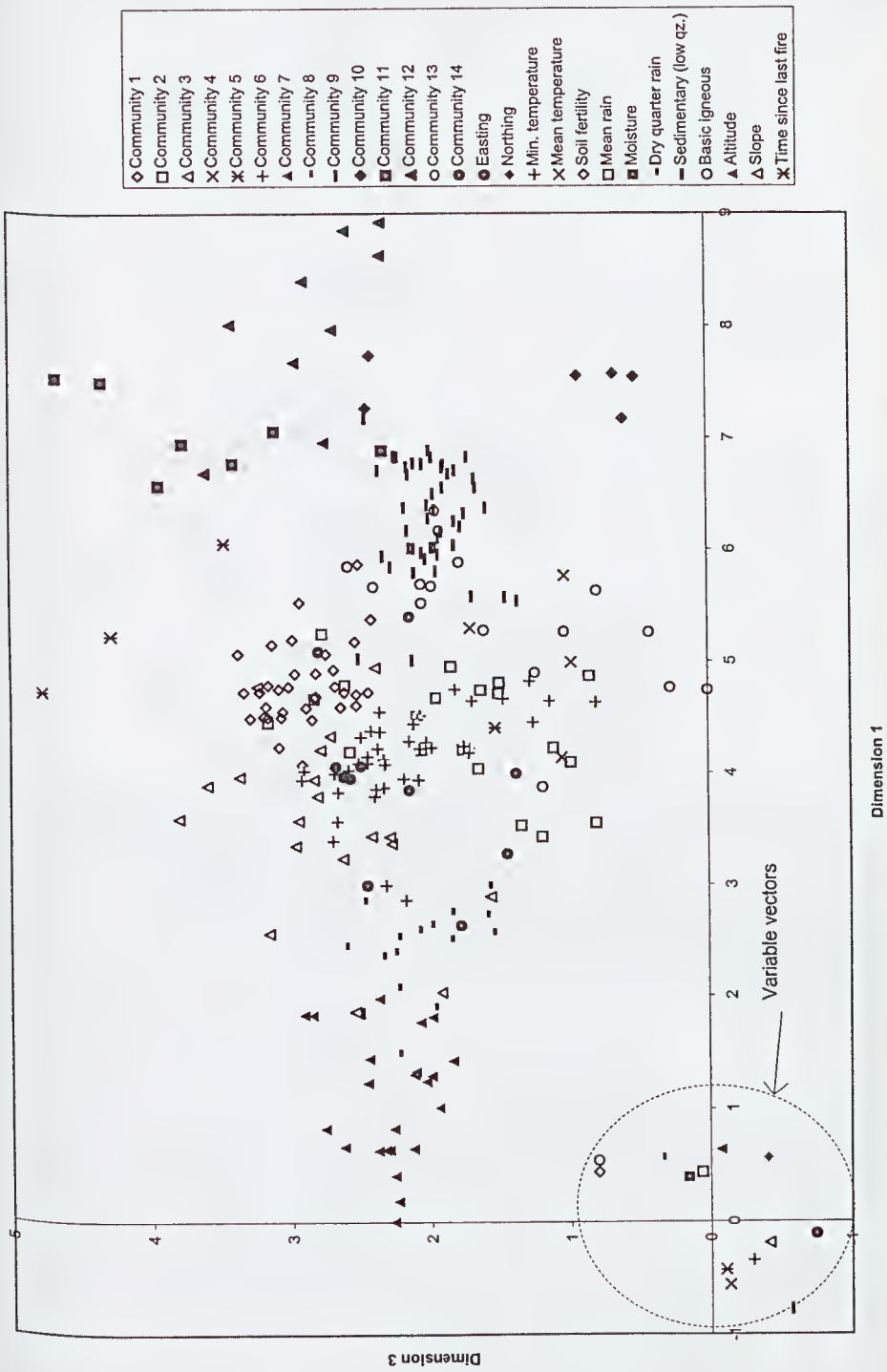

Fig. 5. Ordination of Plots (Dimensions 1 and 3).

Table 7. Average number of species per vegetation community for each plant fire response mechanism (S = Seeder; R = Resprouter; R:S ratio = Resprouter: Seeder ratio; K:U ratio = Known:Unknown fire response ratio).

		Response Mechanism														
Community	Av. no. species	1	2	3	4	5	6	7	8	9	10	11	S*	R* ratio	R:S	K:U ratio
1	47.03	0.00	3.00	0.06	2.50	1.44	0.74	0.00	8.56	4.32	2.03	0.94	11.62	9.94	0.86	0.46
2	37.95	0.15	3.65	0.00	2.10	1.65	0.95	0.05	4.90	3.70	1.90	1.10	8.70	9.55	1.10	0.48
3	56.53	0.05	2.89	0.00	2.21	1.37	1.16	0.05	7.47	5.05	2.79	1.47	10.42	11.32	1.09	0.38
4	28.80	0.20	1.60	0.00	2.60	1.20	0.40	0.00	4.20	2.40	0.00	2.20	6.00	8.80	1.47	0.51
5	35.00	0.33	0.67	0.00	1.67	0.00	0.33	0.00	4.67	1.33	1.67	0.67	5.67	4.00	0.71	0.28
6	51.84	0.00	3.79	0.07	3.02	2.60	0.95	0.05	5.95	4.51	1.70	1.40	9.81	12.53	1.28	0.43
7	51.04	0.00	0.91	0.00	0.17	1.30	0.74	0.17	4.13	2.09	3.57	0.35	5.04	4.83	0.96	0.19
8	49.22	0.11	1.39	0.00	0.50	1.61	1.00	0.39	3.72	3.06	2.67	1.22	5.22	7.78	1.49	0.26
9	42.77	0.17	3.38	0.29	1.79	0.79	0.73	0.00	7.92	4.48	1.46	1.29	11.75	9.08	0.77	0.49
10	26.83	0.00	1.33	0.33	0.50	0.17	0.50	0.00	1.67	2.17	0.17	0.17	3.33	3.50	1.05	0.25
11	35.57	0.00	2.00	0.14	1.14	0.29	1.00	0.00	5.29	2.86	1.86	1.14	7.43	6.43	0.87	0.39
12	32.00	0.00	2.00	0.11	0.78	0.33	0.89	0.00	3.44	2.44	0.67	0.22	5.56	4.67	0.84	0.32
13	35.88	0.44	2.69	0.00	1.69	0.56	1.31	0.00	6.06	3.19	2.63	1.94	9.19	8.69	0.95	0.50
14	22.09	0.09	0.64	0.00	0.55	0.00	0.36	0.00	3.09	2.09	2.36	1.09	3.82	4.09	1.07	0.36

Table 8. Principal axis correlations and Kruskal-Wallis statistics for plant fire response mechanisms.

Fire Response Mechanism	Correlation Coefficient (p)	Kruskal-Wallis statistic (p)
Resprouter	0.5202 **	121.28 **
Seeder	0.4344 **	123.33 **
Resprouter:Seeder	0.3387 **	59.88 **
1	0.2745 **	43.12 **
2	0.3944 **	100.09 **
3	0.3354 **	42.17 **
4	0.5932 **	152.32 **
5	0.6291 **	112.74 **
6	0.1995 *	46.68 **
7	0.2372 **	51.67 **
8	0.3922 **	104 **
9	0.3634 **	97.73 **
10	0.4540 **	73.21 **
11	0.1199 N.S.	67.24 **

N.S. = $p > 0.05$; * = $p < 0.05$; ** = $p < 0.01$

Discussion

Environmental relationships

The principal axis correlations for environmental variables suggest that the overall (linear) floristic pattern is most strongly related to topographic, geographic, edaphic, and, particularly, climatic variables. 'Years Since Logging' and 'Years Since Last Fire' were also relatively highly correlated, but it should be recognised that much of this data is based on subjective field estimates, often several years after a fire had occurred. The number of sites for which this data was available was also relatively low, with 95 sites available for 'Years Since Last Fire' and only 29 for 'Years Since Last Logging'. Several other environmental variables also had significant correlations (including 'Fire Severity'), but the relationships were weak (correlation < 0.5).

Those variables with significant correlations generally also had significant Kruskal-Wallis statistics. While rank order broadly corresponds (e.g. the six variables with the highest correlations also had the highest Kruskal-Wallis statistics), differences in the rank order may be related to differences in the linearity of variables. For example, while altitude had the highest correlation, its Kruskal-Wallis value was only sixth highest. Mean annual temperature, on the other hand, had the second highest correlation and the highest Kruskal-Wallis statistic, possibly reflecting the influence of air inversion in depressions, whether at high or at low altitudes.

The significant correlations and Kruskal-Wallis statistics for 'Years Since Last Fire' and 'Fire Severity' suggest that the vegetation composition of the study area is related to the incidence of fire, at least within the timeframe of the existing observations and

records (maximum 70 years). C. Howard (pers.comm.) comments that major fire events in the late 1950's and early 1960's burnt substantial areas of the Barrington Tops National Park. In addition, sections of the boundaries of the National Park have been subject to regular fires (3–10 year intervals) over the last 100 years which have entered the forests from adjoining grazing lands.

Palaeological studies conducted in the area, however, indicate that the longer term effects of fire are less clear. Dodson (1986), in a study of pollen analyses from eight sites and 57 radiocarbon analyses from nine sites across the Barrington Tops plateau, found that, although the incidence and/or intensity of fires increased from low levels around 3000 BP, 'no major vegetation shifts could be directly attributed to fire'. Similarly, in a palaeological study of Burraga Swamp, south-west of Mt Lumeah, Dodson (1994) found that 'there are no close relationships between charcoal and tree pollen abundance providing some indication that fire has been of minor significance in forest tree dynamics during the last 2000 years'. Any changes that have occurred at Burraga Swamp were instead attributed to logging activities within the catchment and to increased use of the area by day trippers.

Dodson and Myers (1986), among others, showed that Australian pollen types travel in quantity only a few tens of metres. Swamp sediments are therefore likely to record predominantly local fire history of the vegetation. However, the similarity of results from several swamps across the plateaux suggests that the pattern was widespread, a least on the plateaux. This would be despite extensive grazing by cattle and associated burning of the plateau prior to becoming part of the National Park.

Whether the situation is similar at lower altitudes is uncertain in the absence of further palaeological data from those environments. Although fire is obviously a prominent feature, it is, however, not clear that fire has had an influence on the long term composition and layout of the vegetation mosaic within the study area.

Fire response mechanisms

As noted above, correlation coefficients and Kruskal-Wallis statistics were significant for all fire response mechanisms, except for mechanism 11 (insignificant correlation only) (Table 8). High values were obtained particularly for mechanisms 4 (survive a 100% scorch, regenerate through root suckers) and 5 (survive a 100% scorch, regenerate through basal resprouting) and for the two composite mechanisms 'Resprouter' and 'Seeder'.

As shown in Table 7, mechanisms 4 and 5 are particularly prevalent in Vegetation Community 6 (characterised by *Eucalyptus saligna*, *Eucalyptus acmenoides*, *Eucalyptus canaliculata*, *Poa labillardieri*, and *Imperata cylindrica*, located in an arch along the southern boundary of the study area — Fig. 3). However, high 'Resprouter' and 'Seeder' values often occur in the same communities (e.g. Communities 1, 2, 3, 6, 9 and 13). This is not a reflection of the importance of either mechanism, but more related to the higher number of species' matches with the listings of the National Plant Fire Response Register within these vegetation communities, which itself is a function of the average number of species recorded per community (Table 7). Clearly, the larger

the number of species recorded, or the number of species' matches with the Register, the higher the average for the fire response mechanisms. In order to neutralise this bias, the 'Resprouter:Seeder' variable was calculated, which had both a significant correlation coefficient and a significant Kruskal-Wallis statistic (Table 8).

Vegetation communities with particularly low 'Resprouter:Seeder' values include Vegetation Communities 5 and 9 (Table 7). The lower values would indicate that, in general, the maintenance of these vegetation communities requires occasional high intensity fires to maintain the predominance of 'Seeders' over 'Resprouters', as only such fires can damage 'Resprouters' sufficiently to diminish their competitive advantage after a fire (see e.g. Adams & Simmons 1996). In order to develop the fuel load required for hot fires, such fires can only be applied infrequently. A similar strategy could be used to develop a predominance of 'Seeders' over 'Resprouters' in vegetation which does not already contain a predominance of 'Seeders'.

Unfortunately, there are no hard data are available to base the approximately length of the fire intervals. As noted above, there are some data on time interval since last fire and intensity for some plots, but these are largely based on field estimates. In addition, there are no data on fire frequencies for larger areas or longer periods of time. However, based on personal experience, local fire management officers consider a period of 12–20 years to be appropriate for areas away from the rainforest (R.Onfray pers.comm.).

In order to maintain or develop the predominance of 'Resprouters' in vegetation communities with high 'Resprouter:Seeder' values (such as Communities 4 and 8), low intensity fires are prescribed. 'Resprouters' quickly regenerate after such fires, providing heavy competition for 'Seeders'. Local fire management officers consider a period of 5–12 years to be appropriate (R. Onfray pers.comm.).

Low intensity fires are particularly effective in this way if often repeated, resulting in a depletion of the soil seed bank. Effectiveness is also enhanced if the low intensity fire is followed by a drought, resulting in the wilting of any seedlings which manage to establish after fire. In the study area, dry periods are common during late autumn and spring (see above). Thus, a low intensity fire during early autumn/late summer or early spring/late winter would be particularly effective in maintaining or effecting a 'Resprouter' dominated community within the study area.

Vegetation communities with intermediate 'Resprouter:Seeder' values could be maintained or developed using intermediate fire regimes. Thus, a moderate fire in autumn/summer would favour 'Seeders' slightly, relative to low intensity fires, while a moderate fire in spring (followed by the main growing season) would increase this trend.

With any of the above strategies, variability in both space and time would required to minimise the risk of extinction of species with differing requirements (e.g. Bradstock et al. 1995). For example, even in Communities 5 and 9, with very low Resprouter: Seeder ratios, there is still a considerable proportion of plants relying on their ability to resprout as a regeneration mechanism. Furthermore, some of these species may be rare or threatened and their requirements may, therefore, have precedence over those of other species. So far, only one threatened species occurring in the Barrington Tops

area *(Acacia barringtonensis)* appears in the National Plant Fire Response Register. Further research is required to confirm the fire response mechanisms for the other species.

The analysis above can be used as a preliminary framework to determine suitable monitoring points for the experimental establishment of appropriate fire regimes. For example, to determine the effect of different fire regimes (frequencies, timing, intensities) on communities dominated by 'Seeders', monitoring points should be established in locations covered by Vegetation Communities 1, 5, 7, 9, 11, or 14. To determine the effect of different regimes on 'Resprouter' dominated communities, monitoring points should be established in Vegetation Communities 4, 8, and 10. Suitable fire regimes for Vegetation Communities with intermediate 'Resprouter:Seeder' values may than be interpolated from the results.

It should be born in mind that the Kruskal-Wallis statistic and the correlation coefficient of the 'Resprouter:Seeder' variable were relatively low (though significant). The framework outlined in the previous paragraphs is therefore preliminary, and its reliability would benefit from further information on response mechanisms of those species for which these mechanisms are presently unknown. In the absence of such knowledge it may therefore be wiser to establish a number of monitoring points in each of the delineated vegetation communities, with a variety of fire regimes applied in each vegetation community. Apart from monitoring fire characteristics and their effect on the vegetation, such plots could also be used to monitor the build up of fuel loads, for example using litter traps. The rate of fuel load build-up would provide, however, only one of a number of indications (as outlined above) required to establish an appropriate fire regime.

When monitoring, care should be taken to determine the age before seeding of 'Seeder' species. In order to maintain the presence of 'Seeder' species, fires should be avoided before seeding has occurred. Thus, those species requiring the longest period for setting seed are those species which determine the minimum time interval between fires.

Limitations

The study has been limited by a number of factors. The implications of missing plot data on environmental variables and problems associated with limited information on plant fire response mechanisms have been outlined before.

The other main data limitation is the relatively restricted number of plots surveyed within the study area. Although the average plot density (438 ha per plot) was intermediate compared to some other surveys which have been conducted within National Parks of the region (e.g. 805 ha per plot in Yengo National Park —Bell et al. 1993; 63 ha per plot in Tomaree National Park — Bell 1997), the distribution of the plots within the study area was very uneven, even when taking into account any uneven variation of environmental characteristics (Fig. 3). Areas well represented by plots include the Royal National Park, the Cockcrow Mountain area, the Whispering Gully

area, and the central Barrington Tops plateau. The large central part of the study area, on the other hand, contained only a handful of plots.

On the other hand, the study has benefited from the availability of plot data from areas adjacent to the National Parks. Notwithstanding the comments made above, it has improved the generality of the analytical results, including the delineation of vegetation communities and the determination of significant environmental and fire response mechanism variables.

Conclusions

This study has resulted in the delineation of fourteen vegetation communities, based on 890 plant species and 262 plots, of which 154 were located within the boundaries of the Mount Royal and Barrington Tops National Parks. Eight rare or threatened species were recorded within these plots, most of which occur on the plateaux.

The floristic pattern is most closely related to topographic, geographic, edaphic, and, particularly, climatic variables. 'Years Since Logging' and 'Years Since Last Fire' were also relatively highly correlated, but it should be recognised that much of this data is based on subjective field estimates in relatively few sites, often several years after a fire had occurred.

Data on plant fire response mechanisms are also limited, though sufficient to establish significant relationships between such mechanisms and delineated vegetation communities. Given these results, preliminary suggestions were made regarding the intensity of fires required to affect particular floristic outcomes. There is a need for a longer and more extensive record of fires within the study area in order to relate the occurrence of fires with the nature of vegetation communities.

The objectivity of the results obtained from such studies (and hence the appropriateness of their application) would improve if they were based on floristic data from a larger number of plots within the study area than those used in the present study. Such extra plots should particularly be placed in areas presently under-represented within the data set, such as the large central and north-eastern parts of the study area.

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Appendix A. List of species, showing the percentage of plots per community in which each species is present.

Species	Community Number (No. of Plots)													
	1 (34)	2 (20)	3 (19)	4 (5)	5 (3)	6 (43)	7 (23)	8 (18)	9 (48)	10 (6)	11 (7)	12 (9)	13 (16)	14 (11)
Acacia barringtonensis	0	0	0	0	0	0	0	0	6	0	29	22	6	0
Acacia dealbata	0	0	5	0	0	0	0	0	42	17	29	0	25	9
Acacia elata	0	10	0	0	0	0	0	0	0	0	0	0	19	9
Acacia implexa	3	15	0	0	0	28	0	0	0	0	0	0	0	0
Acacia irrorata subsp. *irrorata*	3	25	58	40	0	49	4	6	2	0	0	0	0	0
Acacia maidenii	44	15	37	0	0	35	0	6	2	0	0	0	0	0
Acacia melanoxylon	21	25	11	20	33	9	4	28	44	17	71	22	38	9
Acacia obtusifolia	0	0	0	0	0	5	0	0	0	0	0	0	13	0
Acacia stricta	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Acacia ulicifolia	0	5	0	20	0	5	0	0	2	0	0	0	6	0
Acaena novae-zelandiae	71	15	26	0	100	7	0	0	42	83	14	56	19	0
Acaena Unknown	0	0	0	0	0	0	0	6	10	0	14	0	6	0
Acianthus exsertus	0	10	0	0	0	0	0	0	2	0	0	0	0	0
Acianthus fornicatus	3	5	0	0	0	9	0	0	10	0	0	0	0	0
Acianthus Unknown	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Acmena smithii	3	5	47	0	0	5	70	83	2	0	0	0	0	9
Acradenia euodiiformis	0	0	5	0	0	2	13	0	0	0	0	0	0	0
Acronychia oblongifolia	0	0	5	0	0	7	9	17	2	0	0	0	0	0
Acrotriche latifolia	0	10	0	0	0	2	0	0	0	0	0	0	0	0
Acrotriche serrulata	0	0	0	0	0	0	0	0	4	0	14	0	0	0
Adiantum aethiopicum	24	0	26	0	0	12	4	0	2	0	0	0	6	0
Adiantum diaphanum	0	5	0	0	0	0	4	6	2	0	0	0	0	0
Adiantum formosum	9	0	42	0	0	12	70	28	0	0	0	0	0	0
Adiantum hispidulum	0	0	5	0	0	9	9	6	0	0	0	0	0	0
Ageratina adenophora	0	5	0	0	0	2	4	0	0	0	0	0	0	0
Ageratina riparia	0	0	11	0	0	0	4	0	0	0	0	0	0	0
Agrostis aemula	6	0	0	0	0	0	0	0	0	0	0	0	0	0
Agrostis avenacea var. *avenacea*	9	0	5	0	33	0	0	0	0	0	0	11	0	0
Ajuga australis	9	5	0	0	0	5	0	0	6	17	0	0	0	0
Alangium villosum subsp. *polyosmoides*	0	0	0	0	0	0	43	0	0	0	0	0	0	0
Alectryon subcinereus	0	0	32	0	0	9	70	33	0	0	0	0	0	0
Allocasuarina littoralis	0	0	0	0	0	5	0	0	0	0	0	0	0	0
Allocasuarina torulosa	53	50	47	0	0	70	0	6	0	0	0	0	0	0

Species	Community Number (No. of Plots)													
	1 (34)	2 (20)	3 (19)	4 (5)	5 (3)	6 (43)	7 (23)	8 (18)	9 (48)	10 (6)	11 (7)	12 (9)	13 (16)	14 (11)
Alocasia brisbanensis	0	0	5	0	0	0	4	6	0	0	0	0	0	0
Alphitonia excelsa	0	0	5	0	0	2	0	11	0	0	0	0	0	0
Alyxia ruscifolia	0	5	0	0	0	2	13	17	0	0	0	0	0	0
Ambrosia psilostachya	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Ammobium alatum	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Amyema congener subsp. *congener*	9	0	0	0	0	5	0	0	0	0	0	0	0	0
Amyema pendulum subsp. *pendulum*	9	0	5	0	0	2	0	0	0	0	0	0	0	0
Amylotheca dictyophleba	0	0	0	0	0	0	4	6	0	0	0	0	0	0
Anagallis arvensis	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Aneilema acuminatum	0	0	37	0	0	5	30	17	2	0	0	0	0	0
Aneilema biflorum	0	0	0	0	0	0	9	0	0	0	0	0	0	0
Angophora floribunda	41	10	5	0	0	16	0	0	0	0	0	0	0	0
Angophora subvelutina	0	0	0	0	0	16	0	0	0	0	0	0	0	0
Aphanopetalum	0	0	11	0	0	0	26	0	0	0	0	0	0	0
Araujia sericiflora resinosum	0	0	0	0	0	0	0	6	0	0	0	0	0	0
Archirhodomyrtus beckleri	0	30	0	0	0	5	4	56	0	0	0	0	6	18
Aristida vagans	0	0	0	0	0	9	0	0	0	0	0	0	0	0
Arrhenechthites mixta	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Arthropodium	0	0	0	0	0	0	0	0	2	0	14	0	6	0
Arthropodium milleflorum	44	5	5	20	0	21	0	0	40	17	0	33	13	0
Arthropodium minus	9	0	0	0	0	0	0	0	0	0	0	0	0	0
Arthropodium sp. B	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Arthropteris beckleri	0	0	0	0	0	0	4	0	0	0	0	0	0	0
Arthropteris tenella	0	0	0	0	0	2	87	33	0	0	0	0	0	0
Asperula asthenes	0	0	0	0	0	0	0	0	0	17	0	0	0	0
Asperula conferta	0	0	0	0	0	2	0	0	60	0	0	22	13	0
Asperula gunnii	0	5	0	0	0	0	0	0	4	33	57	44	13	0
Asperula scoparia	6	0	0	0	33	0	0	0	4	0	0	0	6	0
Asplenium australasicum	0	0	16	0	0	0	74	39	0	0	0	0	0	0
Asplenium bulbiferum	0	0	0	0	0	0	4	0	0	0	14	0	0	9
Asplenium flabellifolium	18	5	5	0	0	0	4	0	2	0	14	0	6	0
Asplenium polyodon	0	0	5	0	0	0	0	0	0	0	0	0	0	0
Astrotricha latifolia	0	5	5	0	0	5	4	11	0	0	0	0	13	0

Species	Community Number (No. of Plots)													
	1 (34)	2 (20)	3 (19)	4 (5)	5 (3)	6 (43)	7 (23)	8 (18)	9 (48)	10 (6)	11 (7)	12 (9)	13 (16)	14 (11)
Astrotricha longifolia	0	5	0	0	0	0	0	0	0	0	0	0	0	0
Atherosperma moschatum	0	0	0	0	0	0	0	0	0	0	29	11	0	27
Australina pusilla	0	0	11	0	0	0	9	0	0	0	0	0	0	9
Austrocynoglossum latifolium	38	15	53	0	33	21	4	6	4	0	0	0	0	0
Austromyrtus acmenoides	0	0	0	0	0	0	9	0	0	0	0	0	0	0
Austromyrtus bidwillii	0	0	0	0	0	0	9	0	0	0	0	0	0	0
Backhousia myrtifolia	0	0	16	0	0	0	4	6	0	0	0	0	0	0
Baeckea Unknown	0	0	0	0	0	0	0	0	0	17	0	0	0	0
Baeckea utilis	0	0	0	0	0	0	0	0	0	0	0	33	0	0
Baloghia inophylla	0	0	5	0	0	0	52	6	0	0	0	0	0	0
Banksia integrifolia	0	25	5	20	33	0	0	11	25	0	0	11	57	9
Baumea Unknown	0	0	0	0	0	0	0	0	0	0	0	11	0	0
Berberidopsis beckleri	0	10	0	0	0	0	0	0	2	0	0	0	0	27
Bidens pilosa	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Bidens subalternans	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Billardiera longiflora	0	0	0	0	0	0	0	0	0	0	14	0	6	0
Billardiera scandens	3	40	5	0	0	19	0	0	8	0	0	0	44	0
Blechnum cartilagineum	0	15	11	0	0	7	17	67	2	0	0	0	19	18
Blechnum minus	0	0	0	0	33	0	0	0	2	0	29	22	6	0
Blechnum nudum	0	0	5	0	33	0	0	0	19	0	43	11	19	9
Blechnum patersonii	0	0	0	0	0	0	22	0	0	0	0	0	0	9
Blechnum penna-marina	0	0	0	0	0	0	0	0	2	17	43	33	0	0
Blechnum wattsii	0	5	0	0	0	0	4	0	4	0	14	0	44	36
Bossiaea neo-anglica	0	5	0	20	0	0	0	0	0	0	0	0	0	0
Botrychium australe	6	5	5	0	0	9	0	0	0	0	0	0	0	0
Brachychiton acerifolius	0	0	5	0	0	2	39	17	0	0	0	0	0	0
Brachychiton populneus	0	0	0	0	0	5	0	0	0	0	0	0	0	0
Brachycome diversifolia subsp. *pendulum*	0	0	0	0	0	0	0	0	0	17	0	0	0	0
Brachycome microcarpa	35	10	0	0	0	9	0	0	52	0	29	22	19	0
Brachycome nova-anglica	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Brachycome Unknown	0	0	0	0	0	0	0	0	10	0	0	0	0	0
Brachyloma daphnoides	0	0	0	0	0	0	0	0	0	0	14	0	0	0
Bracteantha bracteata	0	0	0	0	0	5	0	0	17	0	14	0	0	0
Breynia oblongifolia	6	15	32	0	0	67	9	17	0	0	0	0	0	0

Species	Community Number (No. of Plots)													
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Brunoniella australis	0	0	0	0	0	5	0	0	0	0	0	0	0	0
Bulbine bulbosa	0	0	0	0	33	0	0	0	2	0	0	0	0	0
Bulbophyllum exiguum	0	0	5	0	0	0	0	6	0	0	0	0	0	0
Bulbophyllum shepherdii	0	0	5	0	0	0	4	11	0	0	0	0	0	0
Bulbophyllum Unknown	0	0	0	0	0	0	0	6	0	0	0	0	0	0
Bulbostylis densa	0	0	0	0	0	0	0	0	0	0	0	0	6	0
Bursaria longisepala	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Bursaria spinosa	0	5	0	0	0	0	4	17	0	17	0	0	0	0
Caesia parviflora	3	0	0	20	0	0	0	0	0	0	0	0	0	0
Caladenia carnea	0	0	0	0	0	0	0	0	4	0	0	0	0	0
Calanthe triplicata	0	0	5	0	0	0	0	0	0	0	0	0	0	0
Caldcluvia paniculosa	3	25	5	0	0	0	61	83	0	0	0	0	13	18
Callicarpa pedunculata	0	0	0	0	0	0	0	0	0	0	14	0	0	0
Callicoma serratifolia	0	10	11	0	0	0	4	22	0	0	0	0	13	9
Callistemon pallidus	0	0	0	0	0	0	0	0	0	0	29	22	0	0
Callistemon salignus	0	0	11	20	0	12	0	17	0	0	0	0	0	0
Callitriche muelleri	0	0	5	0	0	0	4	0	0	0	0	0	0	0
Callitris macleayana	0	0	0	0	0	2	0	6	0	0	0	0	0	0
Calochlaena dubia	15	30	26	0	0	19	4	11	6	0	0	0	19	0
Canthium coprosmoides	0	0	0	0	0	0	9	0	0	0	0	0	0	0
Cardamine gunnii	0	0	0	0	0	0	0	0	0	0	14	0	0	0
Cardamine lilacina	0	0	0	0	0	0	0	0	4	0	0	0	0	0
Cardamine paucijuga	15	0	0	0	0	0	0	0	8	0	0	22	6	9
Cardamine sp. Y	9	0	0	0	0	0	0	0	4	0	0	22	0	0
Carduus Unknown	0	0	0	0	0	0	0	0	0	0	0	0	0	9
Carex appressa	32	0	26	0	100	7	4	0	15	17	14	22	6	9
Carex breviculmis	12	15	5	40	0	16	0	0	29	0	0	0	25	0
Carex brunnea	0	0	16	0	0	0	22	0	0	0	0	0	0	0
Carex declinata	3	0	5	0	0	0	0	6	2	33	0	0	0	0
Carex fascicularis	0	0	0	0	33	0	0	0	0	0	0	22	0	0
Carex gaudichaudiana	0	0	0	0	0	0	0	0	0	0	0	22	0	0
Carex incomitata	3	0	0	0	0	0	0	0	6	0	14	0	19	0
Carex inversa	53	5	16	0	67	7	4	0	13	17	0	0	0	9
Carex lobolepis	0	0	0	0	67	0	0	0	0	0	0	0	0	0
Carex longebrachiata	21	0	21	0	33	5	9	0	0	0	0	0	0	0
Carex Unknown	0	0	0	0	0	0	0	0	0	0	0	22	0	0
Cassia Unknown	0	0	0	0	0	0	4	0	0	0	0	0	0	0

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Cassine australis	0	0	0	0	0	0	26	11	0	0	0	0	0	0
Cassinia arcuata	0	0	0	20	0	0	0	0	0	0	0	0	0	0
Cassinia compacta	15	0	11	0	0	2	0	0	0	0	0	0	0	0
Cassinia leptocephala	0	5	11	20	0	0	0	0	0	0	0	0	6	0
Cassinia quinquefaria	0	0	5	20	0	0	0	0	0	0	0	0	0	0
Cassinia trinerva	0	0	11	0	0	2	0	0	0	0	0	0	0	0
Casuarina cunninghamiana	0	0	0	0	0	0	9	0	0	0	0	0	0	0
Cayratia clematidea	3	0	26	0	0	23	0	6	0	0	0	0	0	0
Cayratia eurynema	0	0	0	0	0	2	4	0	0	0	0	0	0	0
Celastrus australis	3	0	5	0	0	2	13	0	0	0	0	0	0	0
Celastrus subspicata	0	10	11	0	0	5	0	22	0	0	0	0	0	0
Centaurium erythraea	3	0	0	0	0	2	0	0	0	0	0	0	0	0
Centaurium tenuiflorum	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Centella asiatica	6	0	0	0	0	5	0	0	0	0	0	0	0	0
Centipeda Unknown	0	0	0	0	0	0	0	0	0	17	0	0	0	0
Cephalaralia cephalobotrys	3	5	16	0	0	0	26	56	0	0	0	0	6	9
Cerastium fontanum	0	0	0	0	0	0	0	0	2	17	0	0	0	0
Cerastium glomeratum	3	0	0	0	0	0	0	0	6	0	0	0	0	0
Cerastium semidecandrum	0	0	0	0	0	0	0	0	0	17	0	0	0	0
Ceratopetalum apetalum	0	0	5	0	0	0	0	0	0	17	0	0	0	0
Cheilanthes austrotenuifolia	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Cheilanthes distans	0	0	0	20	0	2	0	0	2	0	0	0	0	0
Cheilanthes sieberi subsp. *sieberi*	0	0	0	60	0	14	0	0	0	0	0	0	0	0
Chiloglottis diphylla	0	0	0	0	0	5	0	0	0	0	0	0	0	0
Chiloglottis pluricallata	0	0	0	0	0	0	0	0	2	33	14	0	6	0
Chiloglottis trilabra	0	5	5	0	0	2	0	0	31	0	14	0	31	0
Chiloglottis Unknown	0	0	0	0	0	0	0	0	15	0	29	11	19	0
Chorizema parviflorum	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Christella dentata	0	0	0	0	0	0	4	0	0	0	0	0	0	0
Cinnamomum oliveri	0	0	0	0	0	0	9	0	0	0	0	0	0	0
Cirsium vulgare	50	15	11	0	67	16	0	6	25	17	0	0	6	0
Cissus antarctica	6	10	47	0	0	51	78	56	0	0	0	0	0	0
Cissus hypoglauca	9	10	58	0	0	49	65	50	0	0	0	0	6	0

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Cissus opaca	0	0	5	0	0	2	0	0	0	0	0	0	0	0
Citriobatus pauciflorus	3	5	53	0	0	14	100	83	2	0	0	0	0	9
Citronella moorei	0	0	5	0	0	0	30	0	0	0	0	0	0	0
Claoxylon australe	0	0	11	0	0	5	39	6	0	0	0	0	0	0
Clematis aristata	44	55	63	20	0	63	4	17	77	17	43	0	50	55
Clematis glycinoides	0	5	16	0	0	12	4	17	0	0	0	0	0	0
Clerodendrum floribundum	0	0	0	0	0	0	0	6	0	0	0	0	0	0
Clerodendrum tomentosum	3	0	11	0	0	16	0	6	0	0	0	0	0	0
Comesperma ericinum	0	0	0	0	0	0	0	0	0	0	0	11	0	0
Comesperma volubile	0	0	0	20	0	0	0	0	0	0	0	0	0	0
Commelina cyanea	6	0	5	0	0	2	4	0	0	0	0	0	0	0
Commersonia fraseri	0	0	5	0	0	0	0	0	0	0	0	0	0	0
Convolvulus erubescens	0	0	0	0	0	7	0	0	0	0	0	0	0	0
Conyza albida	32	10	0	0	0	21	0	0	8	0	0	0	6	0
Conyza bonariensis	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Coprosma hirtella	0	0	0	0	0	0	0	0	4	17	29	0	6	0
Coprosma nitida	0	0	0	0	0	0	0	0	2	0	57	0	6	0
Coprosma quadrifida	18	15	32	0	0	0	0	0	40	0	29	22	63	64
Correa reflexa var. *reflexa*	0	0	5	60	0	0	0	0	0	0	0	0	0	0
Corybas aconitiflorus	0	5	0	0	0	5	0	0	0	0	0	0	0	0
Corybas fimbriatus	0	5	5	0	0	0	0	0	0	0	0	11	0	0
Corybas pruinosus	0	0	5	0	0	5	0	0	0	0	0	0	0	0
Corymbia intermedia	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Corymbia maculata	0	0	5	0	0	7	0	0	0	0	0	0	0	0
Craspedia variabilis	0	0	0	0	0	0	0	0	0	33	14	11	0	0
Crassula sieberiana	9	0	5	20	0	5	0	0	4	0	0	0	0	0
Crepis capillaris	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Croton verreauxii	0	0	11	0	0	2	4	11	0	0	0	0	0	0
Cryptocarya erythroxylon	0	0	0	0	0	0	30	11	0	0	0	0	0	0
Cryptocarya foveolata	0	0	0	0	0	0	22	0	0	0	0	0	0	0
Cryptocarya glaucescens	0	15	26	0	0	9	48	83	0	0	0	0	0	0
Cryptocarya meissneriana	0	10	11	0	0	0	26	22	0	0	0	0	0	0
Cryptocarya microneura	0	0	21	0	0	9	26	50	0	0	0	0	0	0

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Cryptocarya obovata	0	0	5	0	0	0	43	22	0	0	0	0	0	0
Cryptocarya rigida	0	15	16	0	0	14	9	56	0	0	0	0	0	0
Cyathea australis	3	35	5	0	0	2	0	33	6	0	0	0	19	18
Cyathea leichhardtiana	0	0	0	0	0	0	39	17	0	0	0	0	0	9
Cymbidium suave	0	10	16	0	0	35	0	11	0	0	0	0	0	0
Cymbonotus lawsonianus	0	0	0	0	0	0	0	0	2	0	14	0	0	0
Cymbonotus preissianus	0	0	0	0	0	0	0	0	4	17	0	0	0	0
Cymbopogon refractus	6	5	0	40	0	16	0	0	0	0	0	0	0	0
Cynoglossum australe	6	0	0	0	0	0	0	0	2	0	0	0	0	0
Cynoglossum suaveolens	3	0	0	0	33	0	0	0	0	0	0	0	0	0
Cyperus enervis	3	0	0	0	0	2	4	0	0	0	0	0	0	0
Cyperus flaccidus	6	0	5	0	0	0	0	0	0	0	0	0	0	0
Cyperus gracilis	0	0	0	0	0	2	0	0	0	0	0	0	6	0
Cyperus imbecillis	24	0	16	0	0	2	0	0	0	0	0	0	0	0
Cyperus laevis	0	0	5	0	0	12	0	0	0	0	0	0	0	0
Cyperus lhotskyanus	3	0	0	0	33	0	0	0	0	0	0	0	0	0
Cyperus lucidus	6	0	0	0	67	0	4	0	0	0	0	0	6	0
Cyperus sphaeroideus	0	0	0	0	33	0	0	0	0	0	0	11	0	0
Cyperus tetraphyllus	0	0	26	0	0	7	22	17	0	0	0	0	0	0
Cyperus Unknown	3	5	0	0	0	0	4	0	4	0	0	0	0	0
Cytisus scoparius var. *scoparius*	0	0	0	0	0	0	0	0	10	100	0	33	0	0
Danthonia laevis	3	0	0	0	0	0	0	0	2	0	0	0	0	0
Danthonia longifolia	0	5	0	20	0	5	0	0	0	0	0	0	0	0
Danthonia pilosa	34	5	0	0	0	0	0	0	6	17	0	0	0	0
Danthonia tenuior	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Daphnandra sp. A	9	5	26	0	0	5	74	61	0	0	0	0	0	0
Daucus glochidiatus	6	0	5	0	0	9	0	0	0	0	0	0	0	0
Davallia pyxidata	3	0	5	0	0	7	13	11	0	0	0	0	0	0
Daviesia acicularis	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Daviesia genistifolia	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Daviesia ulicifolia	0	0	0	0	0	0	0	0	8	0	0	0	0	0
Deeringia amaranthoides	0	0	11	0	0	0	4	0	0	0	0	0	0	0
Dendrobium fairfaxii	0	0	0	0	0	0	9	17	0	0	0	0	0	0
Dendrobium falcorostrum	0	5	0	0	0	0	0	0	0	0	0	0	6	18

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Dendrobium gracilicaule	0	0	0	0	0	0	13	0	0	0	0	0	0	0
Dendrobium mortii	0	0	0	0	0	0	9	0	0	0	0	0	0	0
Dendrobium pugioniforme	0	0	5	0	0	0	35	22	0	0	0	0	0	18
Dendrobium schoeninum	0	0	0	0	0	0	4	0	0	0	0	0	0	0
Dendrobium tarberi	0	0	0	0	0	0	26	0	0	0	0	0	0	0
Dendrobium tetragonum	0	0	5	0	0	0	0	0	0	0	0	0	0	0
Dendrocnide excelsa	0	5	16	0	0	2	57	11	0	0	0	0	0	0
Dendrophthoe vitellina	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Dennstaedtia davallioides	0	0	26	0	0	0	17	17	0	0	0	0	0	9
Derris involuta	0	0	0	0	0	2	0	0	0	0	0	0	6	0
Desmodium brachypodum	0	10	0	0	0	9	0	0	0	0	0	0	0	0
Desmodium rhytidophyllum	0	15	0	0	0	40	0	0	0	0	0	0	0	0
Desmodium varians	91	45	68	40	33	88	0	0	46	0	0	0	25	0
Deyeuxia acuminata	0	0	0	0	0	0	0	0	0	0	0	0	6	0
Deyeuxia gunniana	0	0	0	0	0	0	0	0	0	0	0	22	6	0
Deyeuxia mesathera	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Deyeuxia monticola	0	0	0	0	0	0	0	0	6	17	0	0	0	0
Deyeuxia parviseta	0	5	0	0	0	0	0	0	2	0	14	0	13	0
Deyeuxia quadriseta	3	0	0	0	0	0	0	0	2	0	0	0	0	0
Deyeuxia reflexa	0	0	0	0	0	0	0	0	2	17	0	0	0	0
Deyeuxia rodwayi	0	0	0	0	0	0	0	0	0	0	0	0	6	0
Dianella caerulea	79	60	74	20	0	83	4	17	35	0	29	0	63	27
Dianella longifolia	3	5	0	0	0	14	0	0	0	0	0	11	0	0
Dianella revoluta	6	0	0	20	0	9	0	6	8	0	0	0	0	0
Dianella tasmanica	15	10	0	0	33	0	0	0	25	0	14	0	31	0
Dichelachne inaequiglumis	0	0	0	0	0	2	0	0	4	0	0	0	0	0
Dichelachne micrantha	18	5	0	20	0	2	0	0	17	0	0	0	0	0
Dichelachne rara	9	10	0	0	0	2	0	0	35	17	0	0	19	0
Dichondra repens	85	15	47	20	0	56	0	0	71	17	0	22	31	18
Dichopogon fimbriatus	0	0	0	0	0	0	0	0	0	17	14	11	0	0
Dichopogon strictus	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Dicksonia antarctica	0	5	11	0	0	0	17	0	10	17	86	0	38	82

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Dictymia brownii	0	0	11	0	0	0	43	28	0	0	0	0	0	0
Digitaria parviflora	0	0	5	0	0	14	0	0	0	0	0	0	0	0
Digitaria ramularis	0	0	0	0	0	5	0	0	0	0	0	0	0	0
Dillwynia juniperina	0	0	0	0	0	0	0	0	0	17	0	0	0	0
Dioscorea transversa	6	5	47	0	0	19	39	56	0	0	0	0	6	0
Diospyros australis	6	15	47	0	0	26	57	78	0	0	0	0	0	0
Diospyros fasciculosa	0	5	0	0	0	0	0	0	0	0	0	0	0	0
Diospyros pentamera	0	0	5	0	0	0	48	11	0	0	0	0	0	0
Diplazium assimile	0	0	0	0	0	0	9	0	0	0	0	0	0	0
Diploglottis australis	0	0	16	0	0	16	74	28	0	0	0	0	0	9
Dipodium punctatum	15	5	0	0	0	2	0	0	0	0	0	0	0	0
Dipodium Unknown	0	0	0	0	0	0	0	0	0	0	0	0	6	0
Diuris sulphurea	0	0	0	0	0	0	0	0	6	0	0	0	0	0
Diuris venosa	0	0	0	0	0	0	0	0	0	17	0	0	0	0
Dodonaea megazyga	0	5	0	0	0	0	0	0	0	0	0	0	0	0
Dodonaea viscosa subsp. *angustifolia*	0	0	5	0	0	0	0	0	0	0	0	0	0	0
Doodia aspera	47	10	74	0	0	40	39	33	6	0	0	0	0	9
Doodia caudata	3	0	0	0	0	5	0	0	0	0	0	0	0	0
Doodia media	3	0	5	0	0	0	4	0	0	0	0	0	0	0
Doryphora sassafras	0	15	26	0	0	0	74	28	2	0	0	0	19	82
Drymophila moorei	0	0	0	0	0	0	0	6	0	0	0	0	0	0
Dysoxylum fraserianum	0	10	5	0	0	14	74	50	0	0	0	0	0	0
Echinopogon caespitosus	0	0	0	0	0	14	0	0	0	0	0	0	0	0
Echinopogon ovatus	65	30	37	0	0	12	4	0	48	0	14	0	6	0
Ehretia acuminata	0	0	5	0	0	5	17	12	0	0	0	0	0	0
Einadia hastata	0	5	0	0	0	0	0	0	0	0	0	0	0	0
Elaeocarpus holopetalus	0	0	0	0	0	0	0	0	8	0	57	11	25	27
Elaeocarpus kirtonii	0	0	5	0	0	0	17	0	0	0	0	0	0	0
Elaeocarpus obovatus	0	0	11	0	0	2	0	0	0	0	0	0	0	0
Elaeocarpus reticulatus	6	20	11	0	0	5	4	56	2	0	0	0	0	0
Elatine gratioloides	0	0	0	0	0	0	0	0	0	0	14	0	0	0
Elatostema reticulatum	0	0	5	0	0	0	35	0	0	0	0	0	0	0
Elattostachys nervosa	0	0	0	0	0	0	4	0	0	0	0	0	0	0
Eleocharis gracilis	0	0	0	0	0	0	0	0	0	0	0	22	0	0
Eleocharis sphacelata	0	0	0	0	0	0	0	0	0	0	0	11	0	0
Elymus scaber	24	0	5	20	0	2	0	0	8	0	0	0	0	0

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Embelia australiana	0	0	0	0	0	0	13	17	0	0	0	0	0	0
Empodisma minus	0	0	0	0	0	0	0	0	0	33	0	44	0	0
Endiandra muelleri	0	0	0	0	0	0	4	0	0	0	0	0	0	0
Endiandra sieberi	0	5	5	0	0	5	17	39	0	0	0	0	0	0
Entolasia marginata	3	10	16	0	0	30	0	0	0	0	0	0	0	0
Entolasia stricta	3	0	0	60	0	21	4	0	0	0	0	0	0	0
Epacris breviflora	0	0	0	0	0	0	0	0	0	33	0	0	0	0
Epacris microphylla var. *rhombifolia*	0	0	0	0	0	0	0	0	0	0	0	33	0	0
Epacris Unknown	0	0	0	0	0	0	0	0	0	33	0	22	0	0
Epilobium billardierianum	6	0	0	0	33	2	0	0	6	0	0	44	0	0
Epilobium gunnianum	0	0	0	0	33	0	0	0	0	0	0	22	0	9
Eragrostis benthamii	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Eragrostis brownii	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Eragrostis leptostachya	0	0	0	20	0	7	0	0	0	0	0	0	0	0
Erigeron pappocromus var. *gunnii*	0	0	0	0	0	0	0	0	0	33	0	0	0	0
Eriochilus cucullatus	0	0	0	0	0	0	0	0	8	0	0	0	0	0
Eucalyptus acmenoides	0	5	16	20	0	56	0	22	0	0	0	0	0	0
Eucalyptus amplifolia	0	0	0	0	0	4	0	0	0	0	0	0	0	0
Eucalyptus biturbinata	0	0	5	0	0	0	0	0	0	0	0	0	0	0
Eucalyptus bridgesiana	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Eucalyptus cameronii	0	5	0	0	0	0	0	6	10	0	0	0	13	0
Eucalyptus campanulata	18	90	21	20	0	30	0	39	8	0	0	0	19	0
Eucalyptus canaliculata	24	0	11	0	0	58	0	0	0	0	0	0	0	0
Eucalyptus carnea	0	0	0	0	0	12	0	0	0	0	0	0	0	0
Eucalyptus cypellocarpa	0	0	5	20	0	0	0	0	0	0	0	0	0	0
Eucalyptus dalrympleana	0	0	0	0	33	0	0	0	50	17	29	44	0	9
Eucalyptus eugenioides	21	5	0	0	0	19	0	0	0	0	0	0	0	0
Eucalyptus fastigata	0	5	0	0	0	0	0	0	48	0	29	11	38	18
Eucalyptus globoidea	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Eucalyptus laevopinea	82	25	42	0	0	19	9	22	19	0	0	0	0	0
Eucalyptus macrorhyncha	0	0	0	20	0	0	0	0	0	0	0	0	0	0
Eucalyptus melliodora	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Eucalyptus microcorys	0	5	21	0	0	16	4	11	0	0	0	0	0	0
Eucalyptus moluccana	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Eucalyptus nitens	0	0	0	0	0	0	0	0	0	0	0	0	0	9

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Eucalyptus nobilis	15	0	5	20	67	0	0	0	27	0	14	11	13	9
Eucalyptus obliqua	18	5	5	0	0	0	0	6	33	0	14	22	88	27
Eucalyptus paniculata	0	0	5	0	0	2	0	0	0	0	0	0	0	0
Eucalyptus pauciflora	3	0	0	0	33	0	0	0	29	50	71	56	0	0
Eucalyptus propinqua	0	0	11	0	0	5	0	0	0	0	0	0	0	0
Eucalyptus punctata	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Eucalyptus quadrangulata	18	10	11	20	0	9	4	6	0	0	0	0	0	0
Eucalyptus radiata	0	0	5	0	0	0	0	0	4	0	14	0	6	0
Eucalyptus resinifera	0	0	0	0	0	2	4	0	0	0	0	0	0	0
Eucalyptus saligna	59	50	53	0	0	58	17	89	4	0	0	0	6	9
Eucalyptus siderophloia	0	0	0	0	0	7	0	0	0	0	0	0	0	0
Eucalyptus stellulata	0	0	0	0	0	0	0	0	0	83	0	22	0	0
Eucalyptus tereticornis	6	0	0	20	0	12	0	0	0	0	0	0	0	0
Eucalyptus viminalis	0	0	0	0	0	0	0	0	2	0	14	0	0	0
Euchiton gymnocephalum	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Euchiton sphaericum	3	0	0	0	0	2	0	0	2	0	0	0	0	0
Euphrasia ciliolata	0	0	0	0	0	0	0	0	0	17	0	0	0	0
Eupomatia laurina	0	5	16	0	0	7	57	72	0	0	0	0	0	0
Euroschinus falcata	0	0	0	0	0	4	0	6	0	0	0	0	0	0
Eustrephus latifolius	50	25	58	0	0	33	0	22	4	0	0	0	19	9
Exocarpos cupressiformis	3	5	0	40	0	5	0	0	0	0	0	0	0	0
Exocarpos strictus	0	0	5	20	0	2	0	0	0	0	0	0	0	0
Facelis retusa	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Ficus coronata	0	0	11	0	0	0	43	0	0	0	0	0	0	0
Ficus obliqua var. *obliqua*	0	0	0	0	0	0	9	0	0	0	0	0	0	0
Fieldia australis	0	0	0	0	0	0	4	0	0	0	0	0	0	0
Fimbristylis dichotoma	0	0	0	0	0	5	0	0	0	0	0	0	0	0
Gahnia aspera	0	5	0	0	0	5	0	11	0	0	0	0	0	0
Gahnia melanocarpa	9	10	26	0	0	16	9	28	6	0	0	11	0	9
Gahnia sieberiana	0	0	0	20	0	5	0	0	8	0	0	0	44	9
Galium binifolium	9	10	11	20	0	0	4	0	10	0	0	0	25	0
Galium ciliare	0	0	0	0	0	0	0	0	4	0	0	0	0	0
Galium curvihirtum	0	0	0	20	0	0	0	0	6	0	0	0	0	0
Galium gaudichaudii	3	0	0	0	0	2	0	0	2	0	14	0	0	0
Galium migrans	3	0	0	0	0	0	0	0	6	0	0	0	6	0

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Galium propinquum	0	10	5	0	0	5	0	0	21	17	29	11	13	18
Galium Unknown	3	0	0	0	0	0	0	0	0	0	0	0	0	0
Gaultheria appressa	0	0	0	0	0	0	0	0	2	0	43	11	0	0
Geijera latifolia	0	0	5	0	0	0	0	0	0	0	0	0	0	0
Geitonoplesium cymosum	38	30	63	0	0	40	13	50	0	0	0	0	0	0
Gentianella diemensis	0	0	0	0	0	0	0	0	4	0	0	0	0	0
Geranium molle	0	0	0	0	0	0	0	0	0	0	14	0	0	0
Geranium neglectum	0	0	0	0	33	0	0	0	2	0	0	22	0	0
Geranium potentilloides	77	30	37	0	100	49	9	0	86	0	28	0	51	18
Geranium solanderi	15	5	5	0	0	7	0	0	4	17	0	11	6	0
Geranium Unknown	0	5	0	0	0	0	0	0	4	0	14	0	0	0
Gleichenia dicarpa	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Glochidion ferdinandi	0	0	11	0	0	7	0	12	0	0	0	0	0	0
Glyceria australis	0	0	0	0	33	0	0	0	0	0	0	0	0	0
Glycine clandestina	88	60	68	40	0	74	4	0	83	0	0	0	25	0
Glycine microphylla	0	0	0	0	0	2	0	0	2	0	0	0	0	0
Glycine sp. A	0	5	0	0	0	0	0	0	0	0	0	0	0	0
Glycine tabacina	0	0	0	0	0	2	0	0	2	0	14	0	0	0
Glycine Unknown	0	0	0	0	0	0	4	0	2	0	0	0	0	0
Gmelina leichhardtii	0	0	0	0	0	2	4	6	0	0	0	0	0	0
Gnaphalium coarctatum	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Gnaphalium gymnocephalum	47	10	11	20	33	16	0	0	33	0	0	33	6	0
Gnaphalium involucratum	0	0	5	0	33	0	0	0	4	17	0	0	0	0
Gnaphalium Unknown	0	0	0	0	0	2	0	0	13	0	0	22	0	0
Gomphocarpus Unknown	0	5	0	0	0	0	0	0	0	0	0	0	0	0
Gomphocarpus fruticosus	0	0	5	0	0	14	0	0	0	0	0	0	0	0
Gonocarpus humilis	12	5	5	20	0	19	0	0	38	0	14	0	38	0
Gonocarpus micranthus	0	0	0	0	0	0	0	0	0	0	14	33	0	0
Gonocarpus montanus	0	0	0	0	0	0	0	0	0	0	14	0	0	0
Gonocarpus oreophilus	0	0	0	20	0	0	4	0	8	0	0	0	6	9
Gonocarpus tetragynus	35	20	11	0	0	19	0	0	23	0	0	0	6	0
Gonocarpus teucrioides	3	20	0	0	0	12	0	6	19	0	14	33	25	9
Gonocarpus Unknown	0	0	0	0	0	0	0	0	2	0	14	0	0	0
Goodenia hederacea	0	0	0	0	0	2	0	0	0	0	0	0	0	0

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Goodenia heterophylla	3	5	0	0	0	14	0	0	0	0	0	0	0	0
Goodenia ovata	0	0	5	0	0	0	0	0	0	0	0	0	13	0
Grammitis billardieri	0	0	5	0	0	0	0	0	0	0	14	0	0	36
Gratiola pedunculata	3	0	0	0	0	0	0	0	0	0	0	0	0	0
Gratiola peruviana	0	0	5	0	67	0	4	0	2	0	29	11	0	9
Gratiola Unknown	0	0	0	0	0	0	0	0	0	0	14	0	0	0
Grevillea arenaria	0	0	5	20	0	0	0	0	0	0	0	0	0	0
Grevillea granulifera	0	0	0	20	0	0	0	0	0	0	0	0	0	0
Guioa semiglauca	0	0	26	0	0	35	39	50	2	0	0	0	0	0
Gymnostachys anceps	9	15	53	0	0	30	65	67	2	0	0	0	0	9
Hakea eriantha	0	0	5	0	0	0	0	0	8	0	0	0	19	0
Hakea microcarpa	0	0	0	0	0	0	0	0	2	67	0	67	0	0
Hakea salicifolia	0	15	5	20	0	0	0	0	0	0	0	0	13	0
Haloragis heterophylla	38	0	11	0	67	0	0	0	2	0	0	0	0	0
Haloragis serra	3	0	0	0	0	0	0	0	0	0	0	0	0	0
Hardenbergia violacea	41	50	11	20	0	65	0	0	19	0	0	0	6	0
Hedycarya angustifolia	6	25	26	0	0	0	0	6	4	0	0	0	6	18
Helichrysum apiculatum	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Helichrysum bracteatum	6	10	5	0	0	12	0	0	19	0	0	0	6	0
Helichrysum dendroideum	0	0	0	0	0	0	0	0	2	0	0	11	0	0
Helichrysum elatum	0	0	0	40	0	2	0	0	0	0	0	0	0	0
Helichrysum scorpioides	9	0	0	0	0	0	0	0	46	33	14	0	0	0
Helichrysum Unknown	0	0	0	0	0	0	0	0	6	0	0	0	0	0
Helicia glabriflora	0	0	5	0	0	0	0	0	0	0	0	0	0	0
Hibbertia acicularis	0	0	0	40	0	0	0	0	0	0	0	0	0	0
Hibbertia aspera	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Hibbertia dentata	29	50	37	0	0	30	0	28	6	0	0	0	13	0
Hibbertia empetrifolia	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Hibbertia linearis	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Hibbertia obtusifolia	6	0	5	20	0	0	0	0	10	0	0	0	0	0
Hibbertia scandens	56	90	68	0	0	79	0	17	10	0	0	0	6	9
Hibiscus heterophyllus	0	0	0	20	0	4	0	0	0	0	0	0	0	0
Histiopteris incisa	3	5	0	0	0	0	0	6	2	0	0	0	19	45
Holcus lanatus	0	0	0	0	33	0	0	0	0	0	0	0	6	0
Hovea linearis	0	0	0	0	0	0	0	0	4	0	0	22	0	0
Hovea longifolia	0	0	0	20	0	0	0	0	0	0	0	0	6	0
Hovea rosmarinifolia	0	0	0	0	0	0	0	0	0	0	0	11	0	0

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Hybanthus enneaspermus	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Hybanthus monopetalus	0	0	0	0	0	0	0	0	13	0	0	11	0	0
Hybanthus stellarioides	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Hydrocotyle acutiloba	62	5	47	0	0	26	0	0	27	17	0	0	0	0
Hydrocotyle geraniifolia	0	0	11	0	0	5	0	0	4	0	0	0	13	0
Hydrocotyle laxiflora	15	20	21	20	0	12	0	6	60	17	71	11	69	27
Hydrocotyle pedicellosa	0	0	0	0	0	0	0	0	0	0	14	0	0	0
Hydrocotyle peduncularis	9	15	5	20	100	16	0	6	19	33	0	22	6	0
Hydrocotyle tripartita	3	0	0	0	0	2	9	0	0	17	0	22	0	0
Hydrocotyle Unknown	0	0	0	0	0	0	0	0	4	17	0	0	0	0
Hymenanthera dentata	18	0	21	0	0	2	13	0	0	0	0	0	13	0
Hymenophyllum australe	0	0	0	0	0	0	0	0	0	0	0	0	0	9
Hymenophyllum cupressiforme	0	0	0	0	0	0	4	6	0	0	0	0	0	36
Hymenosporum flavum	0	0	32	0	0	5	30	11	0	0	0	0	0	0
Hypericum gramineum	24	15	11	80	0	19	0	0	13	33	14	33	0	0
Hypericum japonicum	6	10	0	0	33	2	0	0	10	0	0	22	0	9
Hypochoeris radicata	53	15	0	0	33	14	0	0	40	33	0	56	6	0
Hypolepis glandulifera	9	0	26	0	33	0	0	6	0	0	0	0	0	0
Hypolepis muelleri	0	0	0	0	0	2	4	0	0	0	0	0	0	0
Hypoxis hygrometrica	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Imperata cylindrica	41	55	37	40	67	90	0	0	0	0	0	0	0	0
Indigofera australis	21	20	26	0	0	23	0	0	2	0	0	0	0	0
Isolepis crassiuscula	0	0	0	0	0	0	0	0	0	0	0	22	0	0
Isolepis habra	0	0	0	0	0	0	0	0	0	0	14	11	6	0
Jacksonia scoparia	0	0	5	0	0	2	0	0	0	0	0	0	0	0
Jasminum volubile	0	0	0	0	0	0	4	0	0	0	0	0	0	0
Juncus alexandri subsp. *melanobasis*	0	0	0	0	33	0	0	0	4	0	0	0	0	0
Juncus articulatus	0	0	0	0	33	0	0	0	0	0	0	0	0	0
Juncus australis	0	0	0	0	0	0	0	0	0	0	0	11	0	0
Juncus filicaulis	3	0	0	0	33	0	0	0	0	0	0	0	0	0
Juncus homalocaulis	3	0	0	0	0	0	0	0	0	0	0	0	0	0
Juncus laeviusculus subsp. *laeviusculus*	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Juncus pauciflorus	21	0	16	0	67	2	9	0	0	0	0	11	0	0
Juncus phaeanthus m.s.	0	0	0	0	0	0	0	0	2	0	0	0	0	0

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Juncus prismatocarpus	0	0	0	0	33	0	0	0	0	0	0	0	0	0
Juncus sandwithii	0	0	0	0	0	0	0	0	0	0	0	11	0	0
Juncus sarophorus	9	0	5	0	67	0	0	0	0	0	0	0	0	0
Juncus Unknown	0	10	0	0	0	0	0	0	2	0	14	0	0	9
Juncus usitatus	0	0	0	0	0	2	0	6	0	0	0	0	0	0
Juncus vaginatus	0	0	0	0	0	0	0	0	0	0	0	11	0	0
Kennedia rubicunda	6	20	0	0	0	16	0	0	0	0	0	0	0	0
Kennedia Unknown	0	0	0	0	0	0	0	0	0	0	0	0	6	0
Lagenaria Unknown	0	0	0	0	0	0	0	0	0	0	0	11	0	0
Lagenifera gracilis	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Lagenifera stipitata	21	15	16	20	0	19	0	0	38	0	29	0	44	18
Lantana camara	0	0	5	0	0	7	0	0	0	0	0	0	0	0
Lastreopsis acuminata	3	0	0	0	0	2	30	6	0	0	0	0	0	0
Lastreopsis decomposita	0	0	11	0	0	0	43	22	0	0	0	0	0	0
Lastreopsis microsora	0	0	11	0	0	0	57	6	0	0	0	0	6	0
Lastreopsis munita	0	0	0	0	0	0	4	0	0	0	0	0	0	0
Lastreopsis Unknown	0	0	0	0	0	0	0	11	2	0	0	0	0	0
Legnephora moorei	0	0	0	0	0	0	0	6	0	0	0	0	0	0
Lepidosperma elatius	0	5	0	0	0	0	0	0	0	0	0	0	0	0
Lepidosperma laterale	50	25	42	100	0	44	0	6	15	0	0	0	63	9
Lepidosperma tortuosum	0	0	0	20	0	0	0	0	0	0	0	0	0	0
Leptinella filicula	0	0	0	0	0	0	0	0	35	0	43	0	19	9
Leptospermum argenteum	0	0	0	0	0	0	0	0	2	0	0	44	0	0
Leptospermum polygalifolium	3	0	0	0	0	0	0	0	4	0	43	22	19	0
Leptospermum variabile	0	0	0	40	0	0	0	0	2	0	0	0	0	0
Leucopogon fraseri	6	0	0	0	0	0	0	0	0	0	0	0	0	0
Leucopogon hookeri	0	0	0	0	0	0	0	0	58	67	71	44	13	0
Leucopogon juniperinus	0	0	5	20	0	9	0	0	0	0	0	0	0	0
Leucopogon lanceolatus	29	35	16	40	0	0	0	0	67	0	0	22	69	9
Libertia paniculata	3	0	5	0	0	0	0	0	6	0	0	0	6	0
Libertia pulchella	0	0	0	0	0	0	0	0	0	0	14	11	6	0
Lilaeopsis polyantha	0	0	0	0	0	0	0	0	0	0	14	0	0	0
Lindsaea linearis	0	0	0	0	0	0	0	0	10	0	0	11	0	0
Lindsaea Unknown	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Lissanthe strigosa	0	0	0	20	0	0	0	0	0	0	0	0	0	0
Litsea reticulata	0	10	5	0	0	7	26	44	0	0	0	0	0	0

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Livistona australis	0	0	0	0	0	2	4	0	0	0	0	0	0	0
Lobelia gibbosa	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Lobelia trigonocaulis	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Logania albiflora	0	0	0	40	0	2	0	0	0	0	0	0	0	0
Lomandra confertifolia	0	5	0	0	0	0	0	6	2	0	0	0	0	0
Lomandra filiformis	0	5	0	0	0	18	0	0	4	0	0	0	0	0
Lomandra hystrix	0	0	11	0	0	0	4	6	0	0	0	0	0	0
Lomandra longifolia	97	90	74	80	100	93	0	33	90	0	28	33	88	27
Lomandra multiflora	0	0	0	20	0	7	0	0	2	0	0	0	0	0
Lomandra spicata	0	0	21	0	0	0	87	44	0	0	0	0	0	27
Lomatia arborescens	0	15	0	0	0	0	0	17	10	0	14	11	44	0
Lomatia fraseri	0	10	0	0	0	0	0	0	4	0	14	11	6	0
Lophostemon confertus	0	0	0	0	0	5	0	6	0	0	0	0	0	0
Lotus corniculatus	0	0	0	0	0	0	0	0	4	0	0	0	0	0
Luzula densiflora	0	0	0	0	0	0	0	0	10	17	14	0	0	0
Luzula flaccida	0	0	0	0	0	0	0	0	17	17	14	0	6	0
Luzula ovata	0	0	0	0	0	0	0	0	0	17	0	0	0	0
Luzula Unknown	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Lycopodium deuterodensum	0	0	0	0	0	0	0	0	0	0	0	22	6	0
Lycopodium fastigiatum	0	0	0	0	0	0	0	0	0	33	0	0	0	0
Maclura cochinchinensis	0	0	5	0	0	5	9	6	0	0	0	0	0	0
Malaisia scandens	0	0	0	0	0	2	26	11	0	0	0	0	0	0
Mallotus philippensis	0	0	5	0	0	0	0	0	0	0	0	0	0	0
Marsdenia flavescens	0	0	5	0	0	0	0	0	0	0	0	0	0	0
Marsdenia lloydii	0	0	0	0	0	2	4	6	0	0	0	0	0	0
Marsdenia rostrata	6	5	5	0	0	5	30	6	0	0	0	0	0	9
Maytenus silvestris	21	0	47	20	0	42	0	6	4	0	0	0	0	0
Medicago polymorphua	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Melaleuca styphelioides	6	0	5	0	0	5	0	0	0	0	0	0	0	0
Melia azedarach var. *australasica*	0	0	0	0	0	9	0	0	0	0	0	0	0	0
Melichrus urceolatus	0	0	0	40	0	0	0	0	4	0	0	0	0	0
Melicope micrococca	0	5	16	0	0	16	17	28	0	0	0	0	0	0
Melodinus australis	0	0	5	0	0	0	13	0	0	0	0	0	0	0
Mentha diemenica	24	5	0	0	0	5	0	0	0	0	0	0	0	0
Mentha satureioides	0	0	0	0	0	2	0	0	0	17	0	0	0	0
Micrantheum hexandrum	0	0	0	20	0	0	0	0	0	0	0	0	0	0

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Micrantheum Unknown	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Microlaena stipoides	44	30	37	20	0	33	0	0	42	17	29	0	56	9
Microsorum diversifolium	0	0	0	0	0	0	4	6	0	0	14	0	0	9
Microsorum scandens	0	5	11	0	0	0	65	17	0	0	0	0	0	9
Microtis parviflora	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Microtis unifolia	0	0	0	0	0	0	0	0	4	0	0	0	0	0
Mischocarpus australis	0	0	0	0	0	0	48	22	0	0	0	0	0	0
Mischocarpus pyriformis	0	0	0	0	0	0	0	6	0	0	0	0	0	0
Monotoca scoparia	0	0	0	20	0	0	0	0	0	0	0	22	6	0
Morinda jasminoides	0	5	21	0	0	5	74	44	0	0	0	0	0	9
Muellerina celastroides	3	5	0	0	0	5	0	0	0	0	0	0	0	0
Muellerina eucalyptoides	0	0	0	0	0	7	0	0	0	0	0	0	0	0
Myoporum montanum	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Myoporum Unknown	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Myosotis australis	0	0	0	0	0	0	0	0	19	0	0	11	6	0
Myosotis exarrhena	3	0	0	0	0	0	0	0	2	0	0	0	0	0
Myriophyllum crispatum	0	0	0	0	33	0	0	0	0	0	14	33	0	0
Neolitsea australiensis	0	0	5	0	0	2	4	22	0	0	0	0	0	0
Neolitsea dealbata	0	0	16	0	0	5	61	33	0	0	0	0	0	0
Notelaea longifolia	0	5	21	0	0	4	4	17	8	0	0	0	19	27
Notelaea neglecta	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Notelaea ovata	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Notelaea sp. A	0	0	0	0	0	0	0	0	4	0	0	0	13	0
Notelaea venosa	3	5	5	0	0	0	0	0	6	0	0	0	31	27
Nothofagus moorei	0	15	0	0	0	0	0	0	15	0	14	0	44	100
Olearia alpicola	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Olearia chrysophylla	6	0	5	0	0	0	0	0	0	0	14	33	0	0
Olearia covenyi	0	0	0	0	0	0	0	0	4	0	0	0	19	0
Olearia nernstii	0	5	0	0	0	2	0	0	0	0	0	0	0	0
Olearia oppositifolia	0	0	0	0	0	0	0	0	17	33	57	22	6	0
Olearia phlogopappa	0	0	0	0	0	0	0	0	2	0	14	11	0	0
Olearia Unknown	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Olearia viscidula	0	5	0	0	0	0	0	0	0	0	0	0	0	0
Omalanthus populifolius	0	0	5	0	0	0	0	0	0	0	0	0	0	0
Opercularia aspera	0	0	0	20	0	23	0	0	0	0	0	0	0	0
Opercularia diphylla	0	0	0	0	0	2	0	0	0	0	0	0	0	0

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Opercularia hispida	0	10	0	20	0	2	0	0	0	0	0	11	0	0
Oplismenus aemulus	0	5	5	0	0	37	0	0	0	0	0	0	0	0
Oplismenus imbecillis	41	15	63	20	0	44	17	11	0	0	0	0	6	0
Oreomyrrhis ciliata	0	0	0	0	0	0	0	0	0	17	14	0	0	0
Oreomyrrhis eriopoda	6	0	0	0	0	0	0	0	56	50	43	33	13	0
Orites excelsa	0	0	11	0	0	0	48	39	0	0	0	0	0	27
Oxalis chnoodes	3	20	26	0	0	19	0	0	8	0	0	0	0	0
Oxalis exilis	0	0	5	0	0	0	0	0	0	0	0	0	0	0
Oxalis perennans	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Oxalis radicosa	0	0	0	0	0	0	0	0	0	0	14	0	0	0
Oxalis Unknown	3	0	0	0	0	0	0	0	0	0	0	0	6	0
Oxylobium ilicifolium	3	50	0	20	0	14	0	0	15	0	0	0	25	0
Ozothamnus diosmifolius	6	5	0	20	0	19	0	0	2	0	0	0	0	0
Ozothamnus ferrugineus	3	0	0	0	0	0	0	0	0	0	0	0	0	0
Ozothamnus rufescens	15	0	21	0	0	7	9	0	0	0	0	0	0	0
Ozothamnus Unknown	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Palmeria scandens	0	10	5	0	0	0	70	50	0	0	0	0	6	0
Pandorea jasminoides	0	0	5	0	0	0	0	0	0	0	0	0	0	0
Pandorea pandorana	44	10	58	0	0	35	70	44	4	0	0	0	13	9
Panicum effusum	0	0	0	0	0	5	0	0	0	0	0	0	0	0
Panicum simile	0	5	0	0	0	12	0	0	0	0	0	0	0	0
Papillilabium beckleri	0	0	5	0	0	2	4	11	0	0	0	0	0	0
Pararchidendron pruinosum	0	0	0	0	0	0	9	0	0	0	0	0	0	0
Parsonsia brownii	0	0	0	0	0	0	0	0	0	0	29	0	19	64
Parsonsia induplicata	0	0	5	0	0	2	0	0	0	0	0	0	0	0
Parsonsia sp. A	0	5	0	20	0	2	13	17	0	0	0	0	0	0
Parsonsia straminea	15	15	47	0	0	21	52	61	2	0	0	0	6	9
Parsonsia velutina	0	0	0	0	0	0	39	0	0	0	0	0	0	0
Paspalidium distans	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Paspalum dilatatum	0	0	0	0	33	0	0	0	0	0	0	0	0	0
Passiflora herbertiana	0	0	0	0	0	14	0	0	0	0	0	0	0	0
Passiflora subpeltata	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Patersonia fragilis	0	0	0	0	0	0	0	0	0	0	0	0	6	0
Patersonia glabrata	0	5	0	0	0	0	0	0	0	0	0	0	0	0
Pellaea falcata	38	5	63	0	0	35	43	40	2	0	0	0	0	0

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Pellaea paradoxa	0	5	11	0	0	2	0	0	0	0	0	0	0	0
Pennantia cunninghamii	0	0	5	0	0	0	83	0	0	0	0	0	0	0
Pennisetum alopecuroides	0	0	0	0	33	0	0	0	0	0	0	0	0	0
Peperomia tetraphylla	0	0	0	0	0	0	9	0	0	0	0	0	0	0
Persicaria decipiens	3	0	0	0	33	0	0	0	0	0	0	0	0	0
Persicaria hydropiper	0	0	0	0	0	0	4	0	0	0	0	0	0	0
Persoonia acuminata	0	0	0	0	0	0	0	0	10	0	0	0	6	0
Persoonia chamaepeuce	0	0	0	0	0	0	0	0	0	0	0	22	0	0
Persoonia linearis	9	60	26	20	0	56	0	0	4	0	0	11	38	0
Persoonia media	0	5	0	0	0	0	0	0	0	0	0	0	0	0
Persoonia oleoides	0	5	0	0	0	2	0	0	8	0	0	0	13	0
Persoonia Unknown	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Phalaris canariensis	0	5	0	0	0	0	0	6	0	0	0	0	0	0
Phebalium squameum	0	0	0	0	0	0	0	0	0	0	14	0	0	9
Phragmites australis	0	0	0	0	33	0	0	0	0	0	0	0	0	0
Phyllanthus gasstroemii	0	10	11	20	0	2	4	0	0	0	0	0	0	0
Phyllanthus gunnii	0	0	0	20	0	0	0	0	0	0	0	0	0	0
Phyllanthus similis	3	0	11	0	0	5	0	6	0	0	0	0	0	0
Phyllanthus Unknown	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Physalis minima	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Phytolacca octandra	3	0	0	0	0	0	4	0	0	0	0	0	0	0
Picris hieracioides	29	5	5	0	0	5	0	0	17	0	0	0	0	0
Pimelea curviflora var. *curviflora*	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Pimelea glauca	0	0	0	0	0	0	0	0	0	33	0	0	0	0
Pimelea ligustrina	0	0	5	0	0	0	0	12	8	0	14	0	19	9
Pimelea linifolia	0	5	0	0	0	0	0	0	0	34	0	22	0	0
Pimelea neo-anglica	0	5	0	0	0	0	0	0	0	0	0	0	0	0
Piper novae-hollandiae	0	0	5	0	0	0	39	11	0	0	0	0	0	0
Pittosporum revolutum	15	10	21	0	0	16	4	33	0	0	0	0	0	0
Pittosporum undulatum	12	35	21	20	0	12	9	33	0	0	0	0	0	0
Planchonella australis	0	0	0	0	0	2	13	17	0	0	0	0	0	0
Plantago cladarophylla	0	0	0	0	0	0	0	0	0	0	0	22	0	0
Plantago debilis	65	15	37	0	0	26	0	0	33	0	0	0	25	0
Plantago Unknown	0	0	0	0	0	0	0	0	2	33	0	0	0	0
Platycerium bifurcatum	9	0	16	0	0	12	43	45	0	0	0	0	0	0
Platysace lanceolata	0	5	0	20	0	2	0	0	0	0	0	0	0	0

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Plectorrhiza tridentata	0	0	5	0	0	2	13	6	0	0	0	0	0	0
Plectranthus graveolens	0	0	0	20	0	2	4	0	0	0	0	0	0	0
Plectranthus parviflorus	41	10	42	40	0	67	13	0	2	0	0	0	0	0
Plectranthus Unknown	0	0	5	0	0	0	0	0	0	0	0	0	0	0l
Poa Costiniana	0	0	0	0	0	0	0	0	2	0	0	33	0	0
Poa labillardieri	100	20	42	20	100	74	4	0	15	33	0	0	6	0
Poa queenslandica	0	5	0	0	0	5	4	0	2	0	0	0	0	0
Poa sieberiana	3	25	26	40	0	24	0	0	100	50	71	55	81	18
Poa Unknown	0	0	0	0	0	0	0	0	0	17	29	0	0	0
Podocarpus elatus	0	0	0	0	0	0	0	6	0	0	0	0	0	0
Pollia crispata	0	0	0	0	0	0	30	11	0	0	0	0	0	0
Polygala japonica	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Polymeria calycina	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Polyosma cunninghamii	0	10	5	0	0	0	61	44	0	0	0	0	0	9
Polyphlebium venosum	0	0	0	0	0	0	0	0	0	0	0	0	0	18
Polyscias elegans	0	0	5	0	0	2	4	22	0	0	0	0	0	0
Polyscias murrayi	0	0	5	0	0	0	9	6	0	0	0	0	0	0
Polyscias sambucifolia	18	40	11	0	0	19	0	0	33	0	0	11	50	0
Polystichum australiense	0	0	0	0	0	0	4	0	8	0	14	0	13	36
Polystichum fallax	24	0	26	0	33	0	0	0	0	0	0	0	0	0
Polystichum proliferum	0	5	0	0	0	0	0	0	10	0	43	11	13	18
Pomaderris andromedifolia	0	5	0	0	0	0	0	0	0	0	0	0	0	0
Pomaderris argyrophylla	0	0	0	20	0	0	0	0	0	0	14	0	13	0
Pomaderris eriocephala	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Pomaderris helianthemifolia	0	0	5	20	0	0	0	0	0	0	0	0	0	0
Pomaderris ligustrina	0	0	5	20	0	0	0	0	2	0	0	0	6	0
Poranthera microphylla	38	15	5	20	0	21	0	0	81	33	14	11	25	0
Prasophyllum fuscum	0	0	0	0	0	0	0	0	0	17	0	11	0	0
Pratia pedunculata	15	10	0	0	33	0	0	0	69	17	71	44	44	9
Pratia purpurascens	76	30	21	20	67	51	0	0	29	0	14	0	6	0
Pratia surrepens	0	0	0	0	0	0	0	0	0	0	14	0	0	0
Prostanthera incisa	0	10	0	0	0	0	0	6	0	0	0	0	6	0
Prostanthera lasianthos	0	0	0	0	0	0	0	0	4	0	43	11	19	18
Prunella vulgaris	9	5	0	0	100	2	0	0	2	17	0	22	6	0
Pseuderanthemum variabile	0	5	21	0	0	26	0	11	2	0	0	0	0	0

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Psychotria loniceroides	3	35	47	0	0	51	43	72	0	0	0	0	0	0
Pteridium esculentum	85	90	74	0	100	56	0	6	92	17	29	0	94	9
Pteris tremula	9	0	26	0	0	23	4	17	0	0	0	0	0	0
Pteris umbrosa	0	0	0	0	0	0	52	11	0	0	0	0	0	0
Pterostylis abrupta	0	0	0	0	0	0	0	0	13	0	14	11	19	0
Pterostylis coccina	6	0	0	0	0	0	0	0	35	0	0	0	0	9
Pterostylis curta	12	0	0	0	0	0	0	0	2	0	0	0	0	0
Pterostylis decurva	12	10	0	0	0	0	0	0	13	0	14	0	0	0
Pterostylis furcata	0	0	0	0	0	0	0	0	0	0	14	22	0	0
Pterostylis hispidula	0	0	0	0	0	0	0	0	0	0	0	0	6	0
Pterostylis longifolia	0	10	0	20	0	2	0	0	2	0	0	0	0	0
Pterostylis nutans	0	0	0	0	0	9	0	0	4	0	0	0	0	0
Pterostylis obtusa	0	5	0	0	0	2	0	0	0	0	0	0	0	0
Pterostylis parviflora	0	5	0	20	0	0	0	0	0	0	0	0	0	0
Pterostylis Unknown	0	0	0	0	0	0	0	0	4	0	0	0	0	0
Pultenaea fasciculata	0	0	0	0	0	0	0	0	0	17	0	11	0	0
Pultenaea microphylla	0	0	0	20	0	0	0	0	0	0	0	0	0	0
Pultenaea villosa	0	0	0	0	0	7	0	0	0	0	0	0	0	0
Pyrrosia confluens	0	5	21	0	0	2	61	44	4	0	0	0	6	0
Pyrrosia rupestris	35	15	37	20	0	12	17	67	4	0	14	0	13	55
Pyrrosia Unknown	0	0	5	0	0	0	0	6	2	0	0	0	0	0
Quintinia sieberi	0	5	0	0	0	2	0	6	0	0	0	0	0	18
Ranunculus inundatus	3	10	0	0	0	2	0	0	2	0	0	11	0	0
Ranunculus lappaceus	12	0	0	0	33	5	0	0	35	33	14	11	6	0
Ranunculus pimpinellifolius	0	0	0	0	0	0	0	0	0	17	0	56	0	0
Ranunculus plebeius	41	10	5	0	67	2	0	0	10	17	14	11	0	0
Ranunculus pumilio	0	0	0	0	0	0	0	0	0	17	0	0	0	0
Ranunculus Unknown	0	0	0	0	0	0	0	0	8	0	14	0	0	0
Rapanea howittiana	9	0	53	0	0	14	13	17	0	0	0	0	6	0
Rapanea variabilis	6	15	47	20	0	35	4	56	0	0	0	0	0	0
Restio stenocoleus	0	0	0	0	0	0	0	0	0	33	0	78	0	0
Rhagodia spinescens	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Rhinerrhiza divitiflora	0	0	0	0	0	0	0	6	0	0	0	0	0	0
Rhodamnia rubescens	0	0	16	0	0	21	0	56	0	0	0	0	0	0
Rhodanthe anthemoides	6	0	0	0	0	0	0	0	2	0	0	0	0	0
Rhodomyrtus psidioides	0	0	0	0	0	0	0	6	0	0	0	0	0	0
Ripogonum album	0	0	5	0	0	0	30	11	0	0	0	0	0	0

Species	Community Number (No. of Plots)													
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Ripogonum discolor	0	0	0	0	0	0	4	0	0	0	0	0	0	0
Ripogonum fawcettianum	0	0	0	0	0	0	4	0	0	0	0	0	0	0
Rostellularia adscendens subsp. *adscendens*	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Rubus hillii	3	0	5	0	0	5	22	6	0	0	0	0	0	0
Rubus moorei	0	5	0	0	0	0	4	6	0	0	0	0	0	0
Rubus parvifolius	74	40	37	0	67	67	0	6	67	0	14	22	25	0
Rubus rosifolius	21	25	53	0	33	35	9	28	4	0	0	0	0	0
Rubus sp. A	0	0	5	0	0	0	13	6	0	0	0	0	0	0
Rumex brownii	26	0	16	0	67	0	0	0	2	17	14	0	0	0
Sambucus australasica	0	0	0	0	0	0	9	0	0	0	0	0	0	0
Sambucus gaudichaudiana	0	0	5	0	0	0	0	0	0	0	0	0	0	0
Santalum obtusifolium	0	0	11	0	0	2	0	0	2	0	0	0	0	0
Sarcochilus australis	0	0	5	0	0	0	4	0	0	0	0	0	0	0
Sarcochilus falcatus	3	10	16	0	0	7	57	67	0	0	0	0	0	18
Sarcochilus hillii	0	0	0	0	0	0	0	6	0	0	0	0	0	0
Sarcochilus olivaceus	0	0	5	0	0	0	17	6	0	0	0	0	0	0
Sarcochilus spathulatus	0	0	0	0	0	0	4	11	0	0	0	0	0	0
Sarcochilus Unknown	0	5	0	0	0	0	0	0	0	0	0	0	0	0
Sarcomelicope simplicifolia	0	0	0	0	0	2	4	6	0	0	0	0	0	0
Sarcopetalum harveyanum	3	0	16	0	0	2	22	22	0	0	0	0	0	0
Scaevola albida	3	0	0	0	0	2	0	0	0	0	0	0	0	0
Scaevola hookeri	0	0	0	0	0	0	0	0	0	17	0	22	0	0
Schizomeria ovata	3	25	16	0	0	7	39	72	0	0	0	0	6	18
Schoenus apogon	9	0	0	0	67	5	0	0	6	0	0	11	0	9
Scirpus polystachyus	0	0	0	0	0	0	0	0	0	0	0	22	0	0
Scirpus Unknown	0	0	0	0	0	0	0	0	0	17	0	0	0	0
Scleranthus biflorus	6	0	0	0	0	0	0	0	17	33	0	0	13	0
Scleria mackaviensis	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Scutellaria humilis	9	0	11	20	0	0	0	0	0	0	0	0	0	0
Scutellaria mollis	0	5	21	0	0	5	0	0	4	0	0	0	19	9
Senecio amygdalifolius	24	15	47	0	0	14	4	6	0	0	0	0	0	0
Senecio bipinnatisectus	0	0	5	0	0	0	4	0	0	0	0	0	0	0
Senecio biserratus	3	5	0	0	0	0	0	0	23	0	0	0	19	0
Senecio diaschides	3	10	0	0	0	7	0	0	29	0	0	0	6	0

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Senecio gunnii	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Senecio hispidulus	24	5	5	0	0	0	0	0	2	0	0	0	0	0
Senecio lautus	6	0	0	0	0	7	0	0	29	33	14	11	0	0
Senecio linearifolius	21	25	32	0	0	5	0	0	6	0	0	0	13	0
Senecio macranthus	9	0	0	0	0	0	0	0	0	0	0	0	0	0
Senecio madagascariensis	0	0	5	0	0	5	0	0	0	0	0	0	0	0
Senecio minimus	9	0	11	0	33	0	0	0	2	0	0	0	13	0
Senecio sp. aff. *apargiifolius*	47	10	11	0	0	5	0	0	31	0	0	0	6	0
Senecio sp. E	0	0	0	0	0	0	0	0	2	0	14	22	6	0
Senecio squarrosus	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Senecio Unknown	0	0	0	0	0	7	0	0	8	17	29	0	0	0
Senecio vagus	6	0	5	0	0	0	4	0	0	0	0	0	12	0
Senecio velleioides	0	0	0	0	0	0	0	0	0	0	14	0	0	0
Senna odorata	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Setaria pumila	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Sigesbeckia orientalis	47	15	42	0	0	65	0	6	4	0	0	0	13	0
Sloanea australis	0	0	5	0	0	0	39	22	0	0	0	0	0	0
Sloanea woollsii	0	0	0	0	0	0	30	6	0	0	0	0	0	0
Smilax australis	6	30	68	0	0	28	26	89	60	17	100	11	88	91
Smilax glyciphylla	0	10	5	0	0	0	0	17	0	0	0	0	0	0
Solanum aviculare	3	0	16	0	0	0	4	6	0	0	0	0	6	0
Solanum brownii	12	10	21	20	0	16	0	0	0	0	0	0	0	0
Solanum elegans	0	5	0	0	0	0	0	0	0	0	0	0	0	0
Solanum nigrum	0	0	0	0	0	5	0	0	0	0	0	0	0	0
Solanum opacum	0	0	0	0	0	5	0	0	0	0	0	0	0	0
Solanum prinophyllum	15	0	16	20	0	26	4	6	2	0	0	0	0	0
Solanum pseudocapsicum	0	0	0	0	0	0	0	6	0	0	0	0	0	0
Solanum pungetium	0	0	0	20	0	2	4	0	0	0	0	0	0	0
Solanum stelligerum	6	5	21	20	0	47	4	11	2	0	0	0	0	0
Solanum Unknown	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Solenogyne gunnii	0	0	0	0	0	0	0	0	4	0	0	0	0	0
Sonchus asper subsp. *glaucescens*	3	0	0	0	33	0	0	0	2	0	0	0	0	0
Sonchus oleraceus	3	0	0	0	0	2	0	0	0	0	0	0	0	0
Sorghum leiocladum	12	0	5	0	0	23	0	0	2	0	0	0	0	0
Sparganium subglobosum	0	0	0	0	0	0	0	0	0	0	0	11	0	0

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Spiranthes sinensis	0	0	0	0	0	0	0	0	2	0	0	11	0	0
Sporobolus elongatus	0	0	0	0	0	5	0	0	0	0	0	0	0	0
Sporobolus pyramidalis	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Stackhousia viminea	0	0	0	0	0	5	0	0	0	0	0	0	0	0
Stellaria flaccida	44	10	32	0	0	21	0	0	13	0	57	22	6	9
Stellaria media	6	0	0	0	0	0	0	0	0	0	14	0	0	0
Stellaria pungens	0	0	5	20	0	0	0	0	21	0	0	0	6	0
Stenocarpus salignus	0	10	5	0	0	5	9	17	0	0	0	0	0	0
Stephania japonica	0	0	5	0	0	12	4	0	0	0	0	0	0	0
Sticherus lobatus	0	15	0	0	0	0	0	11	0	0	0	0	31	27
Stipa ramosissima	0	0	5	0	0	0	0	0	0	0	0	0	0	0
Stipa rudis subsp. *nervosa*	0	10	0	20	0	5	0	0	0	0	0	0	0	0
Streblus brunonianus	0	0	5	0	0	0	48	0	0	0	0	0	0	0
Stylidium graminifolium	0	5	0	20	0	0	0	0	6	33	29	22	0	0
Stypandra glauca	0	0	0	20	0	0	0	0	0	0	0	0	0	0
Swainsona galegifolia	3	10	5	0	0	28	0	0	2	0	0	0	0	0
Swainsona Unknown	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Symplocos stawellii	0	0	5	0	0	0	9	0	0	0	0	0	0	0
Symplocos thwaitesii	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Syncarpia glomulifera	0	5	16	20	0	33	0	6	0	0	0	0	0	0
Synoum glandulosum	26	25	58	0	0	44	35	94	2	0	0	0	0	0
Syzygium australe	0	0	0	0	0	0	57	6	0	0	0	0	0	0
Syzygium oleosum	0	0	0	0	0	0	0	6	0	0	0	0	0	0
Taraxacum officinale	12	0	0	0	0	2	0	0	4	0	0	0	0	0
Tasmannia glaucifolia	0	0	0	0	0	0	0	0	2	17	29	22	0	0
Tasmannia insipida	0	10	21	0	0	0	57	83	0	0	0	0	0	9
Tasmannia purpurascens	3	0	0	0	0	0	0	0	27	17	100	22	13	45
Tasmannia stipitata	0	5	0	0	0	0	4	0	10	0	0	0	25	0
Tetrastigma nitens	0	25	11	0	0	35	13	6	0	0	0	0	6	0
Thelymitra circumsepta	0	0	0	0	0	0	0	0	0	0	0	11	0	0
Thelymitra cyanea	0	0	0	0	0	0	0	0	0	0	0	11	0	0
Thelymitra pauciflora	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Themeda australis	12	10	0	20	0	33	0	0	2	0	0	0	0	0
Todea barbara	0	0	0	0	0	0	0	0	0	0	14	0	0	0
Toona ciliata	0	0	11	0	0	2	26	17	0	0	0	0	0	0
Trema aspera	0	0	0	0	0	5	13	0	0	0	0	0	0	0
Tricoryne elatior	0	0	0	0	0	2	0	0	0	0	0	0	0	0

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Trifolium repens	35	5	0	0	67	2	0	0	17	50	0	44	0	0
Trifolium Unknown	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Trimenia moorei	0	0	0	0	0	0	4	0	0	0	0	0	0	0
Tripladenia cunninghamii	0	0	11	0	0	0	0	0	0	0	0	0	0	0
Tristaniopsis collina	3	30	11	0	0	2	9	67	8	0	0	0	0	9
Tristaniopsis laurina	0	0	11	0	0	0	0	6	0	0	0	0	0	0
Trochocarpa laurina	0	30	11	0	0	12	9	67	4	0	0	0	6	18
Trochocarpa sp. A	3	10	0	0	0	0	0	0	17	0	14	0	44	9
Trochocarpa sp. nov.	0	0	0	0	0	0	0	0	0	0	0	0	0	9
Trochocarpa Unknown	0	0	0	0	0	0	0	0	0	0	14	0	0	0
Tylophora barbata	9	15	5	0	0	19	0	6	4	0	0	0	6	0
Tylophora paniculata	0	5	16	0	0	14	0	17	0	0	0	0	6	9
Typha orientalis	0	0	0	0	33	0	0	0	0	0	0	0	0	0
Typhonium brownii	0	0	5	0	0	0	0	0	0	0	0	0	0	0
Uncinia nemoralis	0	0	0	0	0	0	0	0	0	0	14	0	0	9
Urtica incisa	38	5	53	0	67	5	17	28	6	17	14	11	13	45
Utricularia dichotoma	0	0	0	0	0	0	0	0	0	0	0	44	0	0
Verbena bonariensis	0	0	0	0	33	2	0	0	0	0	0	0	0	0
Verbena officinalis	3	0	0	0	33	0	0	0	0	0	0	0	0	0
Verbena rigida	0	5	0	0	0	0	0	0	0	0	0	0	0	0
Vernonia cinerea	6	15	5	0	0	40	0	0	0	0	0	0	0	0
Veronica calycina	50	5	16	0	0	2	0	0	29	17	0	0	6	0
Veronica notabilis	0	5	11	0	0	0	0	6	17	0	43	22	19	64
Veronica persica	0	0	0	0	0	0	0	0	0	17	14	0	0	0
Veronica plebeia	6	5	0	0	0	19	0	0	2	0	0	0	0	0
Veronica sp.C	0	0	5	0	0	5	0	6	6	0	0	0	13	0
Veronica sp. B	0	0	5	0	0	0	0	0	27	33	43	11	38	9
Veronica Unknown	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Vesselowskya rubifolia	0	0	0	0	0	0	9	0	0	0	0	0	0	0
Viola betonicifolia	50	30	0	0	0	30	0	0	75	33	29	11	0	0
Viola hederacea	50	40	63	0	33	30	9	17	79	67	100	33	63	18
Viola sp. A	0	0	0	0	0	0	0	0	0	17	0	11	0	0
Vittadinia cuneata	0	0	0	20	0	0	0	0	0	0	0	0	0	0
Vittadinia dissecta	0	0	0	20	0	0	0	0	0	0	0	0	0	0
Vittadinia tenuissima	3	0	0	0	0	0	0	0	0	0	0	0	0	0
Wahlenbergia ceracea	0	0	0	0	0	0	0	0	25	33	0	22	0	0

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Wahlenbergia gracilis	0	5	0	0	0	2	0	0	0	0	14	0	0	0
Wahlenbergia littoricola	0	10	0	0	0	2	0	0	2	0	0	0	0	0
Wahlenbergia stricta	65	15	11	0	33	10	0	0	42	17	14	33	19	0
Wahlenbergia Unknown	0	0	0	0	0	0	0	0	6	0	0	0	0	0
Waterhousea floribunda	0	0	5	0	0	0	0	0	0	0	0	0	0	0
Westringia eremicola	0	0	0	20	0	0	0	0	0	0	0	0	0	0
Wilkiea huegeliana	0	0	5	0	0	2	9	33	0	0	0	0	0	0
Xanthorrhoea glauca	3	0	0	0	0	0	0	0	0	0	0	0	0	0
Xanthorrhoea Unknown	0	5	0	0	0	0	0	0	0	0	0	0	0	0
Youngia japonica	0	0	0	0	0	0	0	0	4	0	0	0	0	0
Zanthoxylum brachyacanthum	0	0	0	0	0	0	0	6	0	0	0	0	0	0
Ziera smithii subsp. A	0	0	0	0	0	0	0	0	0	0	0	0	6	0
Zieria arborescens	0	0	0	0	0	0	0	6	0	0	0	0	0	0
Zieria pilosa	0	0	0	20	0	0	0	0	0	0	0	0	0	0
Zieria smithii	0	0	5	20	0	5	4	0	0	0	0	0	0	0
Zieria sp. K	0	5	0	0	0	2	0	0	2	0	0	0	6	0

Community 1: *Eucalyptus laevopinea –Eucalyptus saligna* open forest over *Poa labillardieri* grass and herbland

Description

20 Species With Highest Mean Cover and/or Species Common To > 50% of Plots

- Trees *Eucalyptus laevopinea, Eucalyptus saligna, Allocasuarina torulosa, Eucalyptus obliqua, Eucalyptus campanulata, Eucalyptus canaliculata, Angophora floribunda*
- Vines *Desmodium varians, Glycine clandestina, Rubus parvifolius, Hibbertia scandens, Eustrephus latifolius*
- Herbs *Lomandra longifolia, Dichondra repens, Dianella caerulea, Pratia purpurascens, Acaena novae-zelandiae, Geranium potentilloides, Plantago debilis, Hydrocotyle acutiloba, Wahlenbergia stricta, Carex inversa, Hypochoeris radicata, Cirsium vulgare, Lepidosperma laterale, Viola betonicifolia, Viola hederacea*
- Grasses *Poa labillardieri Echinopogon ovatus, Oplismenus imbecillis, Imperata cylindrica, Microlaena stipoides*
- Ferns *Pteridium esculentum*

Rare and Endangered Species

Senecio macranthus, Tasmannia purpurascens.

Relationship to Other Communities

Related to Vegetation Community 2–6 (*Eucalyptus* spp. forest of lower altitudes), but the most distinctive of these communities.

Equivalent Vegetation Types

This Vegetation Community contains elements of the following types:

Binns (1996):

BARov 10.1 (E.saligna)
BARov 17.1 *(E.laevopinea)*
BARov 18 *(E.obliqua)*
BARus 16 *(Acacia irrorata-Doodia aspera)*
BARus 17 *(Imperata cylindrica-Desmodium varians)*

Hager & Benson (1994)

EF011e *(E.saligna-E.quadrangulata)*
EF475g *(E.obliqua-E.laevopinea)*
EF479a *(E.laevopinea)*
EF479e *(E.saligna-E.laevopinea)*
Specht et al. (1995)
199 *(E. laevopinea)*

Distribution

Inside National Park boundaries

Very common in Mount Royal National Park and Cockcrow Mountain areas.

Outside National Park Boundaries

Occurs on well drained, fertile soils on eastern escarpment of the Northern Tablelands.

Environmental Correlates

Occurs on lower slopes, in moderately moist, fertile soils, in moderately steep terrain.

Threats

Exotic Species

Centaurium erythraea, Centella asiatica, Conyza albida, Phytolacca octandra, Sonchus asper, Taraxacum officinale, Verbena officinalis.

Fire

Subject to fires from adjacent farm properties.

Information for Fire Management

Average Total Number of Species: 47.03	Species With Known Plant Responses: 46%	Resprouter: Seeder Ratio: 0.86

Known Seeder Species (including exotics)

Acacia maidenii
Acacia melanoxylon
Asperula scoparia
Billardiera scandens
Breynia oblongifolia
Centaurium erythraea
Cerastium glomeratum
Cirsium vulgare
Clematis aristata
Crassula sieberiana
Daucus glochidiatus
Davallia pyxidata
Dichondra repens
Echinopogon ovatus
Galium binifolium
Galium gaudichaudii
Geranium potentilloides
Glycine clandestina
Gnaphalium gymnocephalum
Gonocarpus tetragynus
Sonchus oleraceus
Helichrysum bracteatum
Hibbertia scandens
Hydrocotyle laxiflora
Hypericum gramineum
Hypochaeris radicata
Hypolepis glandulifera
Indigofera australis
Kennedia rubicunda
Lagenifera stipitata
Oxylobium ilicifolium
Pandorea pandorana
Phytolacca octandr
Pittosporum undulatum
Poranthera microphylla
Pyrrosia rupestris
Rapanea howittiana
Scaevola albida
Schoenus apogon
Senecio diaschides
Senecio hispidulus
Senecio linearifolius
Senecio minimus
Sigesbeckia orientalis
Solanum aviculare
Solanum prinophyllum
Gonocarpus teucrioides
Stellaria flaccida
Stellaria media
Viola hederacea
Wahlenbergia stricta

Community 2: *Eucalyptus campanulata-Eucalyptus saligna* open forest over *Lomandra longifolia*-fern herbland

Description

20 Species With Highest Mean Cover and/or Species Common To > 50% of Plots

- Trees *Eucalyptus campanulata, Eucalyptus laevopine, Allocasuarina torulosa, Eucalyptus saligna, Caldcluvia paniculosa, Callicoma serratifolia, Tristaniopsis collina, Synoum glandulosum*
- Shrubs *Oxylobium ilicifolium, Persoonia linearis, Indigofera australis*
- Vines *Hibbertia scandens, Glycine clandestina, Clematis aristata*
- Herbs *Lomandra longifolia, Prostanthera incisa, Dianella caerulea*
- Ferns *Calochlaena dubia, Pteridium esculentum*

Rare and Endangered Species

None

Relationship to Other Communities

Related to Vegetation Community 1–6 (*Eucalyptus* spp. forest of lower altitudes).

Equivalent Vegetation Types

This Vegetation Community contains elements of the following types:

Binns (1996):
BARov 21 (*E.campanulata*)
BARus 6 *(Tristianopsis collina-Cryptocarya rigida)*
BARus 8 *(Nothofagus moorei)*
BARus 17 *(Imperata cylindrica-Desmodium varians)*

Hager & Benson (1994)
EF505a *(E.campanulata)*
EF505e *(E.campanulata-E.laevopinea)*

Specht et al. (1995)
158 *(E.campanulata-E.laevopinea-E.cypellocarpa - E.obliqua)*

Distribution

Inside National Park boundaries

Throughout eastern and southern parts of the study area. Particularly common on eastern slopes.

Outside National Park Boundaries

Widespread on the Northern Tablelands, extending to North Coast district on high ridges.

Environmental Correlates

Common on moderately steep slopes from 500–1080 m altitude, in moderately moist and fertile soils mostly derived from low quartz sedimentary rock.

Threats

Exotic Species

Ageratina adenophera, Conyza albida, Verbena rigida.

Fire

Subject to fires from adjacent farm properties.

Information for Fire Management

Average Total Number of Species: 37.95	Species With Known Plant Responses: 48%	Resprouter: Seeder Ratio: 1.10

Known Seeder Species (including exotics)

Acacia maidenii
Acacia melanoxylon
Acacia ulicifolia
Adiantum diaphanum
Astrotricha latifolia
Astrotricha longifolia
Banksia integrifolia
Billardiera scandens
Breynia oblongifolia
Cirsium vulgare
Clematis aristata
Desmodium rhytidophyllum
Dichondra repens
Echinopogon ovatus
Galium binifolium
Geranium potentilloides
Glycine clandestina
Gnaphalium gymnocephalum
Gonocarpus tetragynus
Gonocarpus teucrioides
Helichrysum bracteatum
Hibbertia scandens
Hydrocotyle laxiflora
Hypericum gramineum
Indigofera australis
Kennedia rubicunda
Lagenifera stipitata
Leucopogon lanceolatus
Oxylobium ilicifolium
Pandorea pandorana
Pimelea linifolia
Pittosporum undulatum
Poranthera microphylla
Pyrrosia confluens
Pyrrosia rupestris
Senecio diaschides
Senecio hispidulus
Senecio linearifolius
Sigesbeckia orientalis
Stellaria flaccida
Veronica notabilis
Viola hederacea
Wahlenbergia stricta

Community 3: *Eucalyptus saligna-Eucalyptus laevopineaa-Eucalyptus microcorys-Eucalyptus acmenoides* open forest over *Acacia irrorata* shrubland over *Doodia aspera -Oplismenus imbecillus-Lomandra longifolia* herbland

Description

20 Species With Highest Mean Cover and/or Species Common To > 50% of Plots

- Trees *Eucalyptus laevopinea, Eucalyptus microcorys, Eucalyptus saligna, Doryphora sassafras, Backhousia myrtifolia, Eucalyptus acmenoides, Waterhousea floribunda, Synoum glandulosum, Allocasuarina torulosa*
- Shrubs *Acacia irrorata, Citriobatus pauciflorus, Rapanea howittiana*

- Vines *Desmodium varians, Glycine clandestina, Hibbertia scandens, Smilax australis, Clematis aristata, Geitonoplesium cymosum, Viola hederacea, Cissus hypoglauca, Eustrephus latifolius, Pandorea pandorana, Rubus rosifolius*
- Herbs *Dianella caerulea, Lomandra longifolia, Austrocynoglossum latifolium, Gymnostachys anceps, Urtica incisa, Senecio amygdalifolius, Carex longebrachiata*
- Grasses *Oplismenus imbecillis, Poa labillardieri*
- Ferns *Doodia aspera, Pteridium esculentum, Pellaea falcata, Hypolepis glandulifera, Calochlaena dubia*

Rare and Endangered Species

None

Relationship to Other Communities

Related to Vegetation Community 1–6 *(Eucalyptus* spp. forest of lower altitudes).

Equivalent Vegetation Types

This Community has elements of the following types:

Binns (1996):

BARov 3 (Waterhousia floribunda)
BARov 5 *(Backhousia myrtifolia-Tristianopsis laurina)*
BARov 11.1 *(E.acmenoides-Allocasuarina torulosa)*
BARov 17.1 *(E.laevopinea)*
BARus 2 *(Waterhousia floribunda)*
BARus 5 *(Backhousia myrtifolia)*
BARus 16 *(Acacia irrorata-Doodia aspera)*
BARus 17 *(Imperata cylindrica-Desmodium varians)*
BARus 18 *(Poa sieberiana-Desmodium varians)*
BARus 19 *(Poa sieberiana-Lomandra longifolia)*

Hager & Benson (1994)

EF479a *(E.laevopinea)*
EF505e *(E.campanulata)*
EF011e *(E.saligna-E.laevopinea)*
EF479f *(E.laevopinea-E.microcorys)*
RF 208 *(Backhousia myrtifolia-Lophostemon confertus-Tristianopsis laurina)*
RF205 *(Waterhousia floribunda-Tristianopsis laurina)*

Specht et al. (1995)

104 *(Choricarpia leptopetala-Backhousia myrtifolia)*

200 *(E.acmenoides-E.pilularis-E.microcorys- Syncarpia glomulifera)*

Distribution

Inside National Park boundaries

Not common. Occurs on eastern and western slopes, with *E.laevopinea, E.saligna, Lomandra longifolia* common in the west, *and E.microcorys, Backhousia myrtifolia, Waterhousia floribunda, Doodia aspera* more common in the east.

Outside National Park Boundaries

Widespread, but not extensive. Located primarily in riparian zones.

Environmental Correlates

Occurs at lower latitudes (240–760 m), in warm and moderately moist and rugged locations in riparian zones.

Threats

Exotic Species

Ageratina riparia, Lantana camara

Fire

Due to the small areas covered by this community, it is subject to local extinction through fires, particularly if repeated. The moist conditions in which this community occurs, however, suggest that fires do not progress rapidly and are likely to be uncommon.

Information for Fire Management

Average Total Number of Species: 56.53	Species With Known Plant Responses: 38%	Resprouter: Seeder Ratio: 1.09

Seeder Species (including exotics)

Acacia maidenii
Acacia melanoxylon
Asplenium australasicum
Astrotricha latifolia
Banksia integrifolia
Billardiera scandens
Breynia oblongifolia
Cirsium vulgare
Clematis aristata
Crassula sieberiana
Daucus glochidiatus
Davallia pyxidata
Dichondra repens
Dictymia brownii
Echinopogon ovatus
Galium binifolium
Glycine clandestina
Gnaphalium gymnocephalum
Gnaphalium involucratum
Gonocarpus tetragynus
Goodenia ovata
Gratiola peruviana
Hakea eriantha
Helichrysum bracteatum
Hibbertia scandens
Hydrocotyle laxiflora
Hypericum gramineum
Hypolepis glandulifera
Indigofera australis
Lagenifera stipitata
Omalanthus populifolius
Pandorea pandorana
Pittosporum undulatum
Poranthera microphylla
Pyrrosia confluens
Pyrrosia rupestris
Rapanea howittiana
Senecio hispidulus
Senecio linearifolius
Senecio madagascariensis
Senecio minimus
Sigesbeckia orientalis
Solanum aviculare
Solanum prinophyllum
Stellaria flaccida
Veronica notabilis
Viola hederacea

Community 4: *Lepidosperma laterale* — mixed species shrubland (occasionally some trees)

Description

20 Species With Highest Mean Cover and/or Species Common To > 50% of Plots

- Trees *Eucalyptus cypellocarpa, Eucalyptus macrorhyncha* (not in National Park), *Eucalyptus acmenoides*
- Shrubs *Grevillea granulifera* (not in National Park), *Pomaderris helianthemifolia, Westringia eremicola, Acacia irrorata, Gonocarpus oreophilus, Micrantheum hexandrum, Ozothamnus diosmifolius, Pomaderris argyrophylla, Zieria smithii, Correa reflexa, Leptospermum variabile*
- Herbs *Lepidosperma laterale, Carex breviculmis, Hypericum gramineum*
- Grasses *Entolasia stricta, Imperata cylindrica var major*
- Ferns *Cheilanthes sieberi*

Rare and Endangered Species

Grevillea granulifera (not in National Park)

Relationship to Other Communities

Related to Vegetation Community 1–6 (*Eucalyptus* spp. forest of lower altitudes). Very closely related to Vegetation Community 5.

Equivalent Vegetation Types

This Vegetation Community contains elements of the following types:

Binns (1996):

BARus 11 (*Ozothamnus diosmifolius-Gonocarpus oreophilus*)
BARus 20 (*Leptospermum variabile-Pomaderris argyrophylla*)
BARus 22 (*Pomaderris helianthemifolia-Westringia eremicola*)

Hager & Benson (1994)

EF418a (*E.cypellocarpa*)
Specht et al. (1995)
285 (*E.cypellocarpa-E.obliqua-E.radiata*)
290 (*E.fastigata-E.viminalis-E.obliqua-E.cypellocarpa*)

Distribution

Inside National Park boundaries

Rare, on eastern (e.g. Karuah River) and western (Moonan Brook, Carrow Brook) slopes.

Outside National Park Boundaries

Occurs more extensively on the slopes north-west of the National Park boundaries, but only in small patches.

Environmental Correlates

Occurs on relatively dry, rocky, infertile, and rugged sites away from basic igneous rock (tertiary basalt) at altitudes from 630–1130 m.

Threats

Exotic Species

None

Fire

Due to the small areas covered by this community, it is subject to local extinction through fires, particularly if repeated. The rocky substrate on which this community occurs, however, suggest that fires do not progress well.

Information for Fire Management

Average Total Number of Species: 28.80	Species With Known Plant Responses: 51%	Resprouter: Seeder Ratio: 1.47

Seeder Species (including exotics)

Acacia melanoxylon
Acacia ulicifolia
Banksia integrifolia
Clematis aristata
Comesperma volubile
Crassula sieberiana
Dichondra repens
Galium binifolium
Glycine clandestina
Gnaphalium gymnocephalum
Hibbertia acicularis
Hydrocotyle laxiflora
Hypericum gramineum
Lagenifera stipitata
Monotoca scoparia
Opercularia aspera
Oxylobium ilicifolium
Phyllanthus gunnii
Pittosporum undulatum
Poranthera microphylla
Pyrrosia rupestris
Solanum prinophyllum
Solanum pungetium

Community 5: *Eucalyptus nobilis* — mixed sedgeland

Description

20 Species With Highest Mean Cover and/or Species Common To > 50% of Plots

- Trees *Eucalyptus nobilis*
- Vines *Rubus parvifolius*
- Herbs *Acaena novae-zelandiae, Carex appressa, Geranium potentilloides, Hydrocotyle peduncularis, Lomandra longifolia, Prunella vulgaris, Carex inversa, Carex lobolepis, Cirsium vulgare, Cyperus lucidus, Gratiola peruviana, Haloragis heterophylla, Juncus pauciflorus, Juncus sarophorus, Pratia purpurascens, Ranunculus plebeius, Rumex brownii, Schoenus apogon,*

Trifolium repens, Urtica incisa, Carex longebrachiata, Juncus alexandri, Hydrocotyle peduncularis, Bulbine bulbosa, Carex fascicularis, Carex appressa

- Grasses *Poa labillardieri, Imperata cylindrica*
- Ferns *Pteridium esculentum*

Rare and Endangered Species

None

Relationship to Other Communities

Related to Vegetation Community 1–6 (*Eucalyptus* spp. forest of lower altitudes). Very closely related to Vegetation Community 4.

Equivalent Vegetation Types

This Vegetation Community contains elements of the following types:

Binns (1996):

BARus 13 (*Lomandra longifolia-Juncus alexandri*)

Hager & Benson (1994)

EF479d (E.*laevopinea-E.nobilis*)
Specht et al. (1995)
No equivalent

Distribution

Inside National Park boundaries

Rare, in small areas in Mount Cockrow area.

Outside National Park Boundaries

Locally abundant on fertile loamy soils on the eastern slopes of the Northern Tablelands.

Environmental Correlates

Occurs on fertile, moist, moderately steep sites, mostly on soils derived from basic igneous rock.

Threats

Exotic Species

Holcus lanatus, Sonchus asper spp glaucescens, Verbena bonariensis, V.officinalis.

Fire

Due to the small areas covered by this community, it is subject to local extinction through fires, particularly if repeated.

Information for Fire Management

Average Total Number of Species: 35.00	Species With Known Plant Responses: 28%	Resprouter: Seeder Ratio: 0.71

Seeder Species (including exotics)

Acacia melanoxylon	Gratiola peruviana
Asperula scoparia	*Hypolepis glandulifera*
Banksia integrifolia	*Schoenus apogon*
Cirsium vulgare	*Senecio minimus*
Gnaphalium gymnocephalum	*Viola hederacea*
Gnaphalium involucratum	

Community 6: Eucalyptus canaliculata -Eucalyptus acmenoides -Eucalyptus saligna open forest over Imperata cylindrica-Poa labillardieri grassland

Description

20 Species With Highest Mean Cover and/or Species Common To > 50% of Plots

- Trees *Eucalyptus acmenoides, Eucalyptus saligna, Eucalyptus canaliculata, Allocasuarina torulosa, Eucalyptus campanulata, Syncarpia glomulifera, Eucalyptus carnea, Eucalyptus laevopinea*
- Shrubs *Acacia irrorata, Swainsona galegifolia, Breynia oblongifolia, Persoonia linearis, Psychotria loniceroides*
- Vines *Desmodium varians, Dianella caerulea, Rubus parvifolius, Hardenbergia violacea, Clematis aristata, Cissus antarctica, Hibbertia scandens*
- Herbs *Glycine clandestina, Sigesbeckia orientalis, Dichondra repens, Lomandra longifolia, Pratia purpurascens*
- Grasses *Imperata cylindrica, Poa labillardieri, Plectranthus parviflorus, Themeda australis*
- Ferns *Pteridium esculentum*

Rare and Endangered Species

None

Relationship to Other Communities

Related to Vegetation Community 1–5 (*Eucalyptus* spp. forest of lower altitudes).

Equivalent Vegetation Types

This Vegetation Community contains elements of the following types:

Binns (1996):

BARov 13.1 (E.carnea-Allocasuarina torulosa)
BARov 13.2 (*E.carnea-E.maculata*)
BARov 14 (*A.torulosa-E.tereticornis-E.eugenioides*)
BARov 15 (*E.melliodora-E.eugenioides-E.tereticornis*)
BARov 21 (*E.campanulata*)
BARus 17 (*Imperata cylindrica-Desmodium varians*)

Hager & Benson (1994)

EF095a *(E.acmenoides)*
EF095d *(E.acmenoides-E.tereticornis-A.torulosa)*
EF077b *(E.canaliculata-E.eugenioides-A.torulosa)*

Specht et al. (1995)

No equivalent

Distribution

Inside National Park boundaries

Widespread in an arc along the southern edge of the study area.

Outside National Park Boundaries

Elements of this community occur along the North and Central Coast regions at altitudes over 300 m.

Environmental Correlates

Occurs on lower slopes (140–600 m) in warm but dry sites on soils with low fertility derived mostly from low quartz sedimentary rock.

Threats

Exotic Species

Ageratina adenophora, Bidens pilosa, Centaurium erythraea, Centella asiatica, Conyza albida, Conyza bonariensis, Lantana camara, Passiflora subpeltata, Setaria pumila, Solanum nigrum, Sporobolus pyramidalis, Taraxacum officinale, Verbena bonariensis

Fire

Subject to fires from adjacent farm properties.

Information for Fire Management

Average Total Number of Species: 51.84	Species With Known Plant Responses:43 %	Resprouter: Seeder Ratio: 1.28

Seeder Species (including exotics)

Acacia maidenii
Acacia melanoxylon
Acacia obtusifolia
Acacia ulicifolia
Anagallis arvensis
Arthropteris tenella
Astrotricha latifolia
Billardiera scandens
Breynia oblongifolia
Callitris macleayana
Centaurium erythraea
Cirsium vulgare
Clematis aristata
Convolvulus erubescens
Conyza bonariensis
Crassula sieberiana
Daucus glochidiatus
Davallia pyxidata
Hibbertia scandens
Hydrocotyle laxiflora
Hypericum gramineum
Hypochaeris radicata
Indigofera australis
Kennedia rubicunda
Lagenifera stipitata
Opercularia aspera
Opercularia diphylla
Oxylobium ilicifolium
Pandorea pandorana
Pittosporum undulatum
Poranthera microphylla
Pyrrosia confluens
Pyrrosia rupestris
Rapanea howittiana
Scaevola albida
Schoenus apogon
Desmodium rhytidophyllum
Dichondra repens
Dichopogon strictus
Echinopogon ovatus
Galium gaudichaudii
Geranium potentilloides
Geranium solanderi
Glycine clandestina
Gnaphalium gymnocephalum
Gonocarpus tetragynus
Gonocarpus teucrioides
Helichrysum bracteatum
Hibbertia aspera
Hibbertia linearis
Senecio diaschides
Senecio lautus
Senecio linearifolius
Senecio madagascariensis
Sigesbeckia orientalis
Solanum nigrum
Solanum prinophyllum
Solanum pungetium
Sonchus oleraceus
Stackhousia viminea
Stellaria flaccida
Tricoryne elatior
Viola hederacea
Wahlenbergia stricta

Community 7: Rain Forest (Eucalyptus species absent)

Description

20 Species With Highest Mean Cover and/or Species Common To > 50% of Plots

- Trees *Pennantia cunninghamii, Daphnandra species A, Diploglottis australis, Doryphora sassafras, Dysoxylum fraserianum, Acmena smithii, Alectryon subcinereus, Caldcluvia paniculosa, Neolitsea dealbata, Polyosma cunninghamii, Dendrocnide excelsa, Diospyros australis, Syzygium australe, Baloghia inophylla, Acradenia euodiiformis, Schizomeria ovata, Orites excelsa, Sloanea woollsii*
- Shrubs *Citriobatus pauciflorus, Eupomatia laurina, Tasmannia insipida*
- Vines *Cissus antarctica, Morinda jasminoides, Palmeria scandens, Pandorea pandorana, Cissus hypoglauca, Parsonsia straminea*
- Herbs *Lomandra spicata, Gymnostachys anceps, Sarcochilus falcatus*
- Ferns *Arthropteris tenella, Asplenium australasicum, Adiantum formosum, Microsorum scandens, Pyrrosia confluens, Lastreopsis microsora, Pteris umbrosa, Lastreopsis decomposita*

Rare and Endangered Species

Daphnandra sp. A

Relationship to Other Communities

Related to Vegetation Community 8 (*Eucalyptus saligna* dominated wet sclerophyll)

Equivalent Vegetation Types

This Vegetation Community contains elements of the following types:

Binns (1996):

BARov 2.1 (*Acradenia eudiiformis*)
BARov 2.2 (*Sloanea woollsii-Pennantia cunninghamii*)
BARov 6.1 (*Caldcluvia paniculosa-Doryphora sassafras-Schizomeria ovata*)
BARov 6.2 (*Sloanea woollsia-Doryphora sassafras*)
BARov 6.3 (*Sloanea woollsia-Schizomeria ovata-Caldcluvia paniculosa*)
BARov 10.1 (*E.saligna*)
BARus 1 (*Cissus antarctica-Lastreopsis microsora*)
BARus 4 (*Doryphora sassafras*)
BARus 6 (*Tristianopsis collina-Cryptocarya rigida*)
BARus 7 (*Guioa semiglauca-Croton verreauxii*)

Hager & Benson (1994)

RF111 (*Sloanea woolsii-Dysoxylum fraserianum-Heritiera actinophylla-Caldcluvia paniculata*)
RF112 *Schizomeria ovata-Doryphora sassafras-Caldcluvia paniculata-Cryptocarya glaucescens*
RF113 (*Doryphora sassafras-Daphnandra micrantha -Dendrocnide excelsa-Ficus spp.–Toona australis*)

Floyd (1990)

A III 12 (=RF111 of Hager & Benson1994)
A III 13 (=RF112 of Hager & Benson1994)
A III 12 (=RF113 of Hager & Benson1994)
B X 39 (*Schizomeria-Doryphora-Caldcluvia-Orites*)

Distribution

Inside National Park boundaries

Throughout southern parts of the study area.

Outside National Park Boundaries

Not investigated

Environmental Correlates

Occurs in relatively warm sites on lower slopes and in riparian zones on soils with low fertility, derived primarily from low quartz sedimentary rock.

Threats

Exotic Species

Ageratina adenophora, A.riparia, Phytolacca octandra

Fire

Sensitive to fire. However, given the moist conditions in which this community is found, it is unlikely that fire poses a threat, except at the edges.

Information for Fire Management

Average Total Number of Species: 51.04	Species With Known Plant Responses: 19%	Resprouter: Seeder Ratio: 0.96

Seeder Species (including exotics)

Acacia melanoxylon	Gratiola peruviana
Adiantum diaphanum	*Pandorea pandorana*
Arthropteris tenella	*Phytolacca octandra*
Asplenium australasicum	*Pittosporum undulatum*
Astrotricha latifolia	*Pyrrosia confluens*
Breynia oblongifolia	*Pyrrosia rupestris*
Clematis aristata	*Rapanea howittiana*
Davallia pyxidata	*Solanum aviculare*
Dictymia brownii	*Solanum prinophyllum*
Echinopogon ovatus	*Solanum pungetium*
Galium binifolium	*Viola hederacea*
Glycine clandestina	

Community 8: *Eucalyptus saligna* open forest over rainforest understorey

Description

20 Species With Highest Mean Cover and/or Species Common To > 50% of Plots

- Trees *Synoum glandulosum, Eucalyptus saligna, Acmena smithii, Caldcluvia paniculosa, Cryptocarya glaucescens, Diospyros australis, Schizomeria ovata, Tristaniopsis collina, Daphnandra species A, Cryptocarya rigida, Elaeocarpus reticulatus, Rapanea variabilis, Rhodamnia rubescens, Dysoxylum fraserianum, Guioa semiglauca, Eucalyptus campanulata, Endiandra sieberi, Acacia melanoxylon, Neolitsea australiensis, Cryptocarya meissneriana*
- Shrubs *Citriobatus pauciflorus, Tasmannia insipida, Eupomatia laurina, Psychotria loniceroides, Trochocarpa laurina, Archirhodomyrtus beckleri*
- Vines *Smilax australis, Parsonsia straminea, Cephalaralia cephalobotrys, Cissus antarctica, Dioscorea transversa, Cissus hypoglauca, Geitonoplesium cymosum, Palmeria scandens*
- Herbs *Gymnostachys anceps, Sarcochilus falcatus*
- Ferns *Blechnum cartilagineum, Pyrrosia rupestris*

Rare and Endangered Species

None

Relationship to Other Communities

Related to Vegetation Community 7 (rain forest)

Equivalent Vegetation Types

This Vegetation Community contains elements of the following types:

Binns (1996):

BARov 10.1 (*E. saligna*)
BARov 21 (*E. campanulata*)
BARus 6 (*Tristianopsis collina-Cryptocarya rigida*)
BARus 8 (*Nothofagus moorei*)
Hager & Benson (1994)
EF011a (*E. saligna*)
EF011c (*E. saligna-E. laevopinea*)
EF011e (*E. saligna-E. quadrangulata*)

Specht et al. (1995)

159 (*E. saligna-E. microcorys*)

Distribution

Inside National Park boundaries

Throughout the southern parts of the study area. Particularly common in the Whispering Gully area

Outside National Park Boundaries

Occurs along the coastal and escarpment zones northward from the central South Coast.

Environmental Correlates

Occurs in warm, riparian, and other moist locations, on relatively steep slopes and in gullies with moderately fertile soils mostly derived from low quartzose sedimentary rock.

Threats

Exotic Species

None

Fire

Many species within this community are sensitive to fire. Episodic fires are, however, required for the maintenance of this community.

Information for Fire Management

Average Total Number of Species: 49.22	Species With Known Plant Responses: 26%	Resprouter: Seeder Ratio: 1.49

Known Seeder Species (including exotics)

Acacia maidenii	*Hibbertia scandens*
Acacia melanoxylon	*Hydrocotyle laxiflora*
Adiantum diaphanum	*Hypolepis glandulifera*
Arthropteris tenella	*Pandorea pandorana*
Asplenium australasicum	*Pittosporum undulatum*
Astrotricha latifolia	*Pyrrosia confluens*
Banksia integrifolia	*Pyrrosia rupestris*
Breynia oblongifolia	*Rapanea howittiana*
Callitris macleayana	*Sigesbeckia orientalis*
Cirsium vulgare	*Solanum aviculare*
Clematis aristata	*Solanum prinophyllum*
Davallia pyxidata	*Veronica notabilis*
Dictymia brownii	*Viola hederacea*
Gonocarpus teucrioides	

Community 9: *Eucalyptus fastigata-Eucalyptus obliqua-Eucalyptus dalrympleana-Eucalyptus laevopinea-Eucalyptus pauciflora* open forest over *Poa sieberiana* grassland

Description

20 Species With Highest Mean Cover and/or Species Common To > 50% of Plots

- Trees *Eucalyptus fastigata, Eucalyptus obliqua, Eucalyptus dalrympleana, Eucalyptus laevopinea, Eucalyptus pauciflora, Acacia melanoxylon, Eucalyptus nobilis, Eucalyptus dalrympleana ssp heptantha*
- Shrubs *Leucopogon hookeri, Acacia dealbata, Coprosma quadrifida*
- Vines *Glycine clandestina, Clematis aristata, Rubus parvifolius, Smilax australis*
- Herbs *Poranthera microphylla, Viola hederacea, Viola betonicifolia, Dichondra repens, Pratia pedunculata, Asperula conferta, Hydrocotyle laxiflora, Oreomyrrhis eriopoda, Brachycome microcarpa, Lomandra longifolia, Hydrocotyle acutiloba, Wahlenbergia ceracea*
- Grasses *Poa sieberiana*
- Ferns *Pteridium esculentum*

Rare and Endangered Species

Acacia barringtonensis, Tasmannia glaucifolia, Tasmannia purpurascens

Relationship to Other Communities

Related to Vegetation Community 10–13 (*Eucalyptus* spp. forest of higher altitudes)

Equivalent Vegetation Types

This Vegetation Community contains elements of the following types:

Binns (1996):

BARov 18 (E.obliqua)
BARov 19.1 (*E.fastigata*)
BARov 20 (*E.nobilis*)
BARov 21 (*E.campanulata*)
BARov 22 (*E.dalrympleana-Epauciflora*)
BARus 18 (*Poa sieberiana-Desmodium varians*)
BARus 19 (*Poa sieberiana-Lomandra longifolia*)

Hager & Benson (1994)

EF475a (*E.obliqua*)
EF475e(*E.obliqua-E.fastigata*)
EF477a (*E.fastigata*)
EF477c(*E.fastigata-E.nobilis*)
EF414a (*E.nobilis*)
EF413a (*E.dalrympleana*)
EF411a (*E.pauciflora*)

Specht et al. (1995)

290 *(E. fastigat-E. viminalis-E. obliqua-E. cypellocarpa)*

Distribution

Inside National Park boundaries

Common on the plateaux. Extensive north of the study area.

Outside National Park Boundaries

Found primarily on the eastern side of the Tablelands, in moist locations.

Environmental Correlates

Occurs in moderately flat situations between 840–1500 m altitude on soils of moderate fertility.

Threats

Exotic Species

Centaurium tenuiflorum, Conyza albida, Cytisus scoparius var. scoparius, Lotus corniculatus, Sonchus asper spp. glaucescens, Taraxacum officinale

Fire

Subject to wild fires from the west during late winter in dry years

Information for Fire Management

Average Total Number of Species: 42.77	Species With Known Plant Responses: 49%	Resprouter: Seeder Ratio: 0.77

Known Seeder Species (including exotics)

Acacia dealbata
Acacia maidenii
Acacia melanoxylon
Acacia ulicifolia
Adiantum diaphanum
Arrhenechthites mixta
Asperula scoparia
Banksia integrifolia
Billardiera scandens
Cerastium glomeratum
Cirsium vulgare
Clematis aristata
Coprosma nitida
Crassula sieberiana
Dichondra repens
Echinopogon ovatus
Galium binifolium
Galium gaudichaudii
Geranium potentilloides
Geranium solanderi
Glycine clandestina
Gnaphalium gymnocephalum
Gnaphalium involucratum
Gonocarpus tetragynus
Helichrysum dendroideum
Hibbertia scandens
Hybanthus monopetalus
Hydrocotyle laxiflora
Hypericum gramineum
Hypochaeris radicata
Indigofera australis
Lagenifera stipitata
Leucopogon lanceolatus
Lobelia gibbosa
Olearia phlogopappa
Oxylobium ilicifolium
Pandorea pandorana
Poranthera microphylla
Prostanthera lasianthos
Pyrrosia confluens
Pyrrosia rupestris
Schoenus apogon
Senecio diaschides
Senecio hispidulus
Senecio lautus
Senecio linearifolius
Senecio minimus
Sigesbeckia orientalis
Solanum prinophyllum
Gonocarpus teucrioides
Gratiola peruviana
Hakea eriantha
Helichrysum apiculatum
Helichrysum bracteatum
Stellaria flaccida
Veronica notabilis
Viola hederacea
Wahlenbergia stricta

Community 10: *Eucalyptus stellulata* open forest over *Cytisus scoparius* var. *scoparius* shrubland over *Poa sieberiana* grassland

Description

20 Species With Highest Mean Cover and/or Species Common to > 50% of Plots

- Trees *Eucalyptus stellulata, Eucalyptus pauciflora*
- Shrubs *Cytisus scoparius, Hakea microcarpa, Leucopogon hookeri, Epacris breviflora, Tasmannia purpurascens, Hakea microcarpa*
- Herbs *Acaena novae-zelandiae, Viola hederacea, Oreomyrrhis eriopoda, Trifolium repens, Dichondra repens, Senecio lautus, Chiloglottis pluricallata, Asperula gunnii, Empodisma minus*
- Grasses *Poa sieberiana, Poa labillardieri*

Rare and Endangered Species

Asperula asthenes, Euphrasia ciliolata, Tasmannia glaucifolia, Tasmannia purpurascens

Relationship to Other Communities

Related to Vegetation Communities 9–13 (*Eucalyptus* spp. forest of higher altitudes)

Equivalent Vegetation Types

This Vegetation Community contains elements of the following types:

Binns (1996):

No equivalent

Hager & Benson (1994)

EF411b *(E.pauciflora-E.stellulata)*

Specht et al. (1995)

247 *(E.paucifflora-E.stellulata-E.camphora)*

Distribution

Inside National Park boundaries

Restricted to riparian zones and edges of sub-alpine swamps on plateaux

Outside National Park Boundaries

Throughout cold and frosty sites on the Tablelands.

Environmental Correlates

Occurs on cold, flat, and damp sites at high altitudes (1430-1500 m), on fertile soils derived primarily from basic igneous rock

Threats

Exotic Species

Cytisus scoparius

Fire

Subject to wild fires from the west during late winter in dry years

Information for Fire Management

Average Total Number of Species: 26.83	Species With Known Plant Responses: 25%	Resprouter: Seeder Ratio: 1.05

Known Seeder Species (including exotics)

Acacia dealbata	*Hydrocotyle laxiflora*
Acacia melanoxylon	*Hypericum gramineum*
Cerastium semidecandrum	*Hypochaeris radicata*
Cirsium vulgare	*Pimelea linifoli*
Clematis aristata	*Poranthera microphylla*
Dichondra repens	*Viola hederacea*
Geranium solanderi	*Wahlenbergia stricta*
Gnaphalium involucratum	

Community 11: *Eucalyptus pauciflora* open forest over *Tasmannia purpurescens* shrubland over mixed herbland

Description

20 Species With Highest Mean Cover and/or Species Common To > 50% of Plots

- Trees *Eucalyptus pauciflora, Elaeocarpus holopetalus, Eucalyptus dalrympleana, Eucalyptus viminalis*
- Shrubs *Acacia melanoxylon, Tasmannia purpurascens, Leucopogon hookeri, Coprosma nitida, Olearia oppositifolia, Acacia dealbata, Elaeocarpus holopetalus, Leptospermum polygalifolium, Callistemon pallidus,*
- Vines *Smilax australis*
- Herbs *Viola hederacea, Hydrocotyle laxiflora, Pratia pedunculata, Asperula gunnii, Stellaria flaccida, Gaultheria appressa*
- Grasses *Poa sieberiana*
- Ferns *Polystichum proliferum, Dicksonia antarctica*

Rare and Endangered Species

Acacia barringtonensis, Tasmannia glaucifolia, Tasmannia purpurascens

Relationship to Other Communities

Related to Vegetation Communities 9–13 (*Eucalyptus* spp. forest of higher altitudes). Closely related to Vegetation Community 12, which tends to occur adjacent to it.

Equivalent Vegetation Types

This Vegetation Community contains elements of the following types:

Binns (1996):

BARov 9 *(Elaeocarpus holopetalus-Atherosperma moschatum-Leptospermum polygalifolium)*
BARov 19.2 *(Acacia dealbata-E.fastigata)*
BARus 10 *(Acacia dealbata-Prostanthera lasianthos)*
BARus 12 *(Leptospermum polygalifolium-Elaeocarpus holopetalus)*

Hager & Benson (1994)

EF411c *(E. pauciflora-E. dalrympleana)*
EF411d *(E. pauciflora-E. viminalis)*
RF 410 *(Elaeocarpus holopetalus)*

Specht et al. (1995)

237 *(E.delegatensis-E.pauciflora-E.rodwayi)*
242 *(E.pauciflora-E.rubida)*
251 *(E.nova-anglica-E.pauciflora-E.dalrympleana)*

Distribution

Inside National Park boundaries

Restricted to riparian/moist zones in highest parts of the Barrington Tops plateau.

Outside National Park Boundaries

Occurs throughout the Tablelands region.

Environmental Correlates

Occurs on cold, flat, and damp sites at high altitudes (1310-1540 m), on fertile soils almost always derived from basic igneous rock

Threats

Exotic Species

None

Fire

Subject to wild fires from the west during late winter in dry years

Information for Fire Management

Average Total Number of Species: 35.57	Species With Known Plant Responses: 39%	Resprouter: Seeder Ratio: 0.87

Seeder Species (including exotics)

Acacia dealbata	*Lagenifera stipitata*
Acacia melanoxylon	*Olearia phlogopappa*
Clematis aristata	*Poranthera microphylla*
Coprosma nitida	*Prostanthera lasianthos*
Echinopogon ovatus	*Pyrrosia rupestris*
Galium gaudichaudii	*Senecio velleioides*
Geranium potentilloides	*Stellaria flaccida*

Gonocarpus teucrioides
Gratiola peruviana
Hydrocotyle laxiflora
Hypericum gramineum
Stellaria media
Veronica notabilis
Viola hederacea
Wahlenbergia stricta

Community 12: Sedgeland

Description

20 Species With Highest Mean Cover and/or Species Common To > 50% of Plots

- Trees *Eucalyptus pauciflora, Eucalyptus dalrympleana*
- Shrubs *Leptospermum argenteum, Epacris* Unknown, *Cytisus scoparius, Baeckea utilis, Persoonia chamaepeuce, Hakea microcarpa*
- Herbs *Restio stenocoleus, Empodisma minus, Lomandra longifolia, Carex gaudichaudiana, Eleocharis sphacelata, Isolepis habra, Scirpus polystachyus, Hypericum gramineum, Acaena novae-zelandiae, Hypochoeris radicata, Ranunculus pimpinellifolius*
- Grasses *Poa costiniana, Poa sieberiana, Deyeuxia gunniana*

Rare and Endangered Species

Acacia barringtonensis, Plantago cladarophylla, Tasmannia glaucifolia, Tasmannia purpurascens

Relationship to Other Communities

Related to Vegetation Community 9–13 (*Eucalyptus* spp. forest of higher altitudes). Closely related to Vegetation Community 11, which tends to occur adjacent to it

Equivalent Vegetation Types

This Vegetation Community contains elements of the following types:

Binns (1996):

BARov 17.1 (E.laevopinea)
BARov 18 *(E.obliqua)*
BARus 18 *(Poa sieberiana-Desmodium varians)*
BARus 19 *(Poa sieberiana-Lomandra longifolia)*
BARus 23 *(Restio stenocoleus-Leptospermum argenteum)*

Hager & Benson (1994)

EF411c *(E.pauciflora-E.dalrympleana)*

Specht et al. (1995)

No equivalent

Distribution

Inside National Park boundaries

Restricted to wetlands on the plateaux

Outside National Park Boundaries

Occurs throughout frost flats in the Tableland region

Environmental Correlates

Occurs on cold, flat, damp, partially inundated sites at high altitudes (1200–1460 m), on fertile soils often derived from basic igneous rock

Threats

Exotic Species

Cytisus scoparius var. *scoparius*

Fire

Subject to wild fires from the west during late winter in dry years, though hindered by the wet conditions of this vegetation community

Information for Fire Management

Average Total Number of Species: 32.00	Species With Known Plant Responses: 32%	Resprouter: Seeder Ratio: 0.84

Known Seeder Species (including exotics)

Acacia melanoxylon
Comesperma ericinum
Dichondra repens
Gnaphalium gymnocephalum
Gonocarpus micranthus
Gonocarpus teucrioides
Gratiola peruviana
Helichrysum dendroideum
Hybanthus monopetalus
Hydrocotyle laxiflora
Hypericum gramineum
Hypochaeris radicata
Leucopogon lanceolatus
Monotoca scoparia
Olearia phlogopappa
Pimelea linifolia
Poranthera microphylla
Prostanthera lasianthos
Schoenus apogon
Senecio lautus
Stellaria flaccida
Utricularia dichotoma
Veronica notabilis
Viola hederacea
Wahlenbergia stricta

Community 13: *Eucalyptus obliqua* open forest over *Poa sieberiana* — mixed ferns herbland

Description

20 Species With Highest Mean Cover and/or Species Common To > 50% of Plots

- Trees *Eucalyptus obliqua, Eucalyptus fastigata, Eucalyptus campanulata*
- Shrubs *Coprosma quadrifida, Banksia integrifolia, Tasmannia stipitata, Acacia dealbata, Leucopogon lanceolatus, Astrotricha latifolia, Acacia elata*
- Vines *Smilax australis, Clematis aristata*
- Herbs *Lomandra longifolia, Hydrocotyle laxiflora, Dianella caerulea, Lepidosperma laterale, Viola hederacea*
- Grasses *Poa sieberiana, Microlaena stipoides*

- Ferns *Sticherus lobatus, Blechnum wattsii, Polystichum proliferum, Calochlaena dubia, Cyathea australis, Pteridium esculentum*

Rare and Endangered Species

Tasmannia purpurascens, Acacia barringtonensis

Relationship to Other Communities

Related to Vegetation Communities 10–13 (*Eucalyptus* spp. forest of higher altitudes)

Equivalent Vegetation Types

This Vegetation Community contains elements of the following types:

Binns (1996):

BARov 18 (E.obliqua)
BARov 19.1 *(E.fastigata)*
BARus 18 *(Poa sieberiana-Desmodium varians)*
BARus 19 *(Poa sieberiana-Lomandra longifolia)*
Hager & Benson (1994)
EF475a *(E.obliqua)*
EF475e *(E.obliqua-E.fastigata)*
EF425f *(E.obliqua-E.campanulata)*

Specht et al. (1995)

290 *(E.fastigat-E.viminalis-E.obliqua-E.cypellocarpa)*
158 *(E.campanulata-E.laevopinea-E.cypellocarpa-E.obliqua)*

Distribution

Inside National Park boundaries

Common at higher altitudes in central and northern parts of the study area

Outside National Park Boundaries

Found throughout the Central and Southern New England Tableland bioregion above 600-900 m.

Environmental Correlates

Occurs on moderately steep slopes from 1000 - 1380 m altitude, on soils of medium fertility derived primarily from low quartzose sedimentary rock.

Threats

Exotic Species

Conyza albida, Holcus lanatus

Fire

Not threatened by fire

Information for Fire Management

Average Total Number of Species: 35.88	Species With Known Plant Responses: 50%	Resprouter: Seeder Ratio: 0.95

Known Seeder Species (including exotics)

Acacia dealbata	*Helichrysum bracteatum*
Acacia melanoxylon	*Hibbertia scandens*
Acacia obtusifolia	*Hydrocotyle laxiflora*
Acacia ulicifolia	*Lagenifera stipitata*
Asperula scoparia	*Leucopogon lanceolatus*
Astrotricha latifolia	*Monotoca scoparia*
Banksia integrifolia	*Oxylobium ilicifolium*
Billardiera scandens	*Pandorea pandorana*
Cirsium vulgare	*Poranthera microphylla*
Clematis aristata	*Prostanthera lasianthos*
Coprosma nitida	*Pyrrosia confluens*
Dichondra repens	*Pyrrosia rupestris*
Echinopogon ovatus	*Rapanea howittiana*
Galium binifolium	*Senecio diaschides*
Geranium potentilloides	*Senecio linearifolius*
Geranium solanderi	*Senecio minimus*
Glycine clandestina	*Sigesbeckia orientalis*
Gnaphalium gymnocephalum	*Solanum aviculare*
Gonocarpus tetragynus	*Stellaria flaccida*
Gonocarpus teucrioides	*Veronica notabilis*
Goodenia ovata	*Viola hederacea*
Hakea eriantha	*Wahlenbergia stricta*

Community 14: *Nothofagus moorei* closed forest

Description

20 Species With Highest Mean Cover and/or Species Common To > 50% of Plots

- Trees *Nothofagus moorei, Doryphora sassafras, Eucalyptus fastigata, Schizomeria ovata, Caldcluvia paniculosa, Quintinia sieberi, Elaeocarpus holopetalus, Eucalyptus obliqua, Callicoma serratifolia, Eucalyptus dalrympleana,*
- Shrubs *Acacia elata, Trochocarpa sp. nov., Coprosma quadrifida*
- Vines *Smilax australis, Parsonsia brownii, Clematis aristata*
- Herbs *Prostanthera lasianthos, Veronica notabilis*
- Ferns *Dicksonia antarctica, Blechnum wattsii, Blechnum cartilagineum, Pyrrosia rupestris*

Rare and Endangered Species

Tasmannia purpurascens

Relationship to Other Communities

Most distinctive Vegetation Community of all communities delineated. Usually adjacent to any of Vegetation Communities 9–13, 7 or 8

Equivalent Vegetation Types

This Vegetation Community contains elements of the following types:

Binns (1996):

BARov 8 (Nothofagus moorei-Doryphora sassafras)
BARov 18 *(E.obliqua)*
BARus 8 *(Nothofagus moorei)*

Hager & Benson (1994)

RF 404 *(Nothofagus moorei-Elaeocarpus holopetalus)*
RF403 *(Nothofagus moorei-Doryphora sassafras-Orites excelsa-Caldcluvia paniculata)*

Specht et al. (1995)

38 *(Nothofagus moorei-Cryptocarya foveolata-Orites excelsa)*

Distribution

Inside National Park boundaries

Common on slopes at higher altitudes in central and northern parts of the study area

Outside National Park Boundaries

Found in restricted areas from the Barrington Tops to the Border Ranges.

Environmental Correlates

Occurs slopes or depressions at high altitudes (1040–1380 m), on moderately fertile soils and in moist conditions

Threats

Exotic Species

None

Fire

The edges of stands on the plateau are subject to wild fires in late winter during dry years.

Information for Fire Management

Average Total Number of Species: 22.09	Species With Known Plant Responses: 36%	Resprouter: Seeder Ratio: 1.07

Seeder Species (including exotics)

Acacia dealbata
Acacia melanoxylon
Banksia integrifolia
Clematis aristata
Dichondra repens
Geranium potentilloides
Gonocarpus teucrioides
Gratiola peruviana
Hibbertia scandens
Hydrocotyle laxiflora
Lagenifera stipitata
Leucopogon lanceolatus
Pandorea pandorana
Prostanthera lasianthos
Pyrrosia rupestris
Schoenus apogon
Stellaria flaccida
Veronica notabilis
Viola hederacea

Estuarine wetlands distribution along the Parramatta River, Sydney, 1788–1940: implications for planning and conservation

Lynette C. McLoughlin

McLoughlin, L.C. (Graduate School of the Environment, Macquarie University, NSW Australia, 2109) 2000. Estuarine wetlands distribution along the Parramatta River, Sydney, 1788–1940: implications for planning and conservation. Cunninghamia *6(3): 579–610.* This study examined a variety of written, cartographic and pictorial historical materials to document the extent and distribution of inter-tidal wetlands and riparian vegetation along the Parramatta River and its bays from 1788 (first settlement in Port Jackson) to c. 1940 (when documentation by aerial photographs commenced). Although data available do not permit detailed quantitative analysis, and no single source is definitive, in total they yield a more detailed picture has hitherto been available. These historical sources indicate that in the 19th century extensive mudflats and saltmarsh communities dominated the inter-tidal zone, with mangroves more limited to creek fringes and some patches in bays for much of the period. In the upper river from Subiaco Creek to Parramatta, there is no evidence for the presence of mangroves until the 1870s. Following settlement and increased sedimentation, inter-tidal mudflats expanded, mangroves colonised up river and out onto mudflats in bays in the latter part of the 19th century, followed by expansion into saltmarsh in the 20th century.

This study demonstrates that some of the assumptions regarding the former extent of mangroves on which recent studies and foreshore plans are based are inappropriate. The historical data, combined with subsequent aerial photographic data, provides an enlarged database that needs to be taken into account in the formulation of conservation management plans and restoration strategies.

Keywords: foreshore vegetation, mangrove colonisation, saltmarsh, reclamation, revegetation, wetland zonation, wetland conservation, Australia, Sydney Harbour

Introduction

Over much of the period from European settlement in 1788, Sydney Harbour and Parramatta River were viewed from a utilitarian perspective. However, from the 1970s, as waterfront industries and port activities relocated and shipbuilding declined, changes in land use led to a greater appreciation of the waterways' aesthetic and recreational values. With the Clean Waters Act in 1970 and early measures to improve the river's water quality, interest in the ecological values of the Parramatta River and its foreshores also emerged. The National Trust of Australia (NSW) published *Parameters for the River* (Lynch et al. 1976) to stimulate such interest in improving degraded aspects of the river: its foreshores, landscapes, remnant vegetation, habitats and fauna.

Improvement has included protection and conservation of a number of vegetation remnants, particularly wetlands, while the restoration of indigenous vegetation along foreshores has been included in many planning documents of the 1980s and 1990s. However, wetlands restoration requires an understanding of their former distribution and composition, as do policies and decisions for foreshore vegetation management. Studies have used aerial photographs to document former wetland communities on the Parramatta River and to trace changes in their distribution (Thorogood 1985, DEP 1986b, Moss 1987, Clarke & Benson 1988; Burchett & Pulkownik 1996), but the earliest aerial photographs date from the 1930s and there has been very little work in tracing other, earlier, sources.

This paper examines the source material and evidence available to determine the extent and distribution of inter-tidal wetlands and shoreline vegetation along the Parramatta River arm of the Sydney Harbour system from time of European settlement in 1788, up to 1940. The evidence consists of written descriptions, pictorial evidence such as paintings, drawings and photographs, and cartographic evidence in maps and plans. Each is by nature fragmentary and incomplete in coverage but in total yields a more detailed picture than the assumptions and unsourced statements on which the understandings of recent studies are built. While the primary goal is to shed light on the foreshores at the time of European settlement, this paper will also consider the changes that occurred up to 1940. Implications of a longer-term historical view for planning and conservation are considered following analysis of the historical data.

Study area

Parramatta River commences a short distance up the Sydney Harbour system from Sydney Cove, extending from its junction with the Lane Cove River at Greenwich/Balmain to the weir at Parramatta (see Fig. 1 for all cited locations). The river lies along the southern edge of the Hornsby Plateau, massive vertically jointed Hawkesbury sandstone capped with Wianamatta Group shales, in which the river's northern tributaries have cut deep steep-sided valleys. Sandstone is the surface geology along much of the northern shores of the river and outliers of the sandstone plateau occur on the southern side of the river in decreasing prominence from Balmain to Uhrs Point. On this south side of the river the sandstone is broken by large embayments, where tributary creeks draining catchments substantially of shale built larger patches of alluvium and inter-tidal mudflats.

From Homebush Bay upstream the geology changes dramatically on the southern side. Here the catchment consists entirely of Wianamatta shales, which have a low resistance to denudation processes and result in subdued terrain. High levels of sediment stripped from the shales produced large deposits of alluvium along the river and its tributaries between Homebush Bay and Clay Cliff Creek, and associated inter-tidal mudflats, particularly from Homebush Bay to Duck River.

Much of the shoreline has been disturbed by clearing and reclamation but patches of wetland can be found in a number of locations, notably Homebush Bay, Newington, Duck River, Majors and Yaralla Bays on the south side, and Meadowbank and Ermington on the north (Register of the National Estate n.d. a–g). These wetlands are

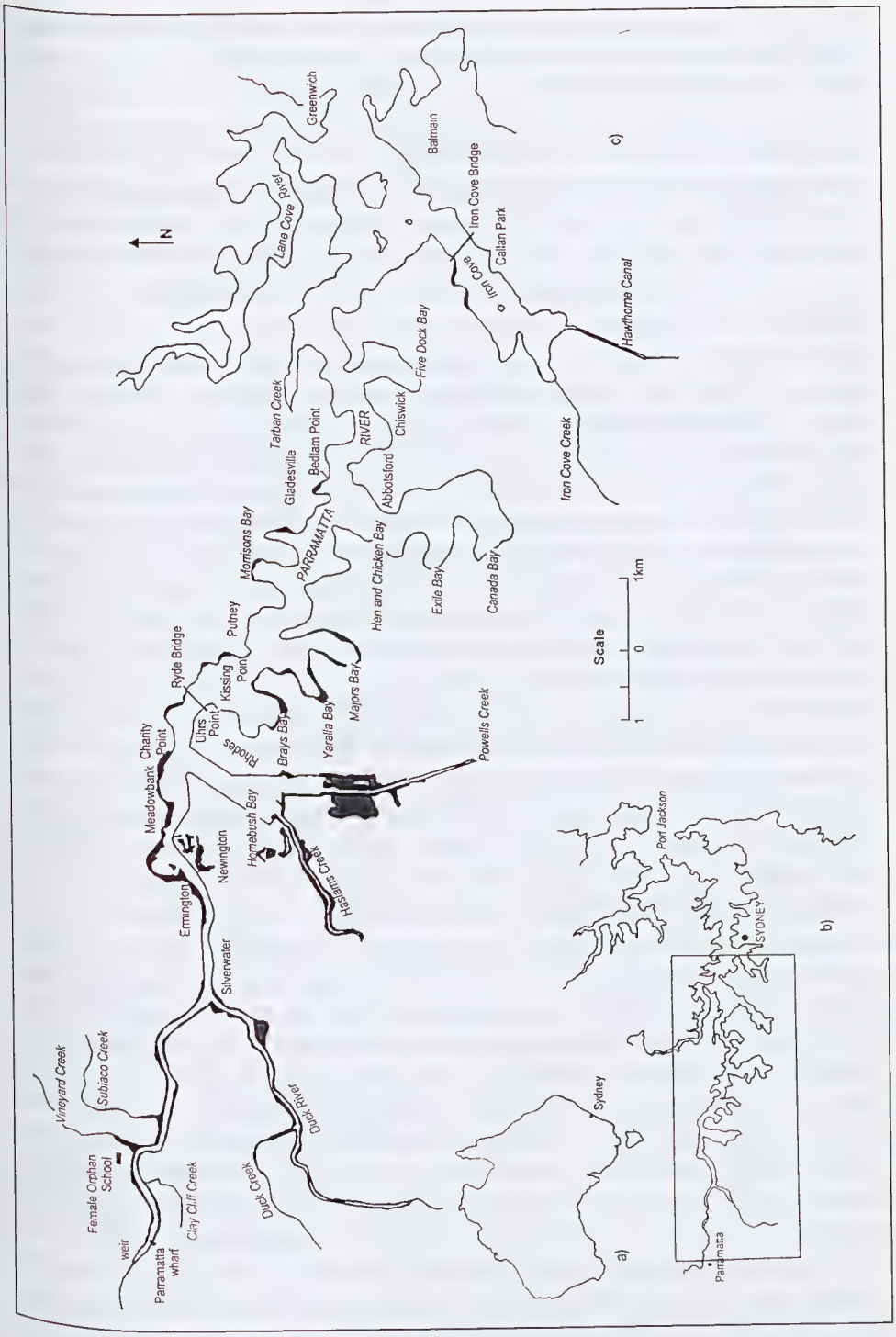


Fig. 1. The Study Area (a) geographic location; (b) the Sydney Harbour system; (c) Parramatta River from Greenwich/Balmain to the weir at Parramatta including: ■ mangrove distribution in the 1990s (from NSW Land Information Centre 1994 aerial photograph series with some later ground confirmation).

predominantly mangroves and mudflats with some small areas of saltmarsh at Homebush Bay and Newington and casuarinas at Newington. There is also a mangrove fringe along many sections of the river above Homebush Bay as far as Parramatta.

Existing reconstructions and perceptions of former wetland distribution

Reconstruction of the historical distribution of Parramatta River inter-tidal wetlands and shoreline vegetation has relied largely on three elements: aerial photographs series dating from the 1930s, ecological inference from present distribution patterns, and some key assumptions which have been repeated through a variety of studies of the past twenty years.

Two of the most pervasive of these assumptions are that the river was lined with mangroves to the limit of tidal influence at Parramatta (except perhaps for rocky headlands) prior to the impact of European development, and that present areas of mangroves are therefore small remnants of this former extent. This gained currency with Lynch et al.'s (1976) statement that 'the mangrove community is recorded to have once extended in a continuous strip for at least 60 kilometres up Parramatta River and in its bays stretching southwards.' This 'recorded' observation is unsourced and undated but forms part of Lynch et al.'s description of the river's former wetlands and foreshore vegetation. The mid-channel length of the Parramatta River is 19 km from the weir at Parramatta to Greenwich. The description, not located by this study, clearly refers to a shoreline distance, but along which parts of the river, whether confined only to the bays on the southern side and whether based on the 1788 shoreline or at some later stage, is not clear. Yet in many subsequent studies of the river and its vegetation, this unsourced description has been reproduced as the only 'evidence' for the river's pre-1940s foreshore vegetation (SPCC 1979, Department of Environment and Planning (DEP) 1986a, 1986c, Moss 1987, Latham 1988, MacDonald 1990, EDAW & Environmental Partnership 1996). Only one of these (DEP 1986a) noted that the original statement was unsourced.

Perceptions of the historical extent of saltmarsh vary. Saltmarsh is taken to include rush, sedge and reed communities as well as herbs and grasses, as defined by Adam et al. (1988) and all rarely distinguished separately in historical sources. According to Hamilton (1919) large areas of saltpan mudflats were also once found in or adjacent to saltmarsh areas above regular high tide. Clarke and Hannon (1967) analysed the geomorphic factors affecting development of halophytic vegetation in other estuaries in the Sydney region. They concluded that the small size and rugged sandstone geology of these catchments produced little run-off and low sediment yields, thus limiting areas for the development of saltmarsh. This has also been applied to the Parramatta River (Lynch et al. 1976, EDAW and Environmental Partnership 1997), despite a quite different geology on the southern shores and in the upper reaches, with the conclusion that saltmarsh existed there also only as a narrow band behind the mangrove zone (DEP 1986c). Clarke and Benson (1988), using historical evidence, note that saltmarsh was extensive at Homebush Bay but few other studies discuss the former extent of saltmarsh. General terms, such as 'extensive wetlands' or 'extensive mangroves and saltmarsh' are more common descriptions (Karskens 1986, Benson and Howell 1990, Connell Wagner 1995, Register of the National Estate n.d., a–g).

There is also limited consideration of the extent of inter-tidal mudflats. A 1975 study notes (unsourced), that the heads of bays such as Iron Cove, Hen and Chicken, Yaralla, Majors and Homebush 'originally had extensive mudflats' (University of Sydney 1975) but above Homebush Bay the areas filled behind the seawalls were 'previously (intertidal) mangrove swamps'. The most consistent recognition of the presence and extent of mudflats is for Homebush Bay where they were 'extensive' and bordered by mangroves and saltmarsh (Benson & Howell 1990, Webster & Kachka 1992, Olympic Coordination Authority 1997).

These perceptions of former wetland distribution have been reinforced by ecological inference from current distribution, as in the description of the river at Parramatta at the time of first settlement: 'there would have been mangroves, *Avicennia marina*, below Church Street' (Benson & Howell 1990). They are also reinforced by concepts of wetland spatial zonation and temporal succession first described for the Sydney district by Hamilton (1919) and Collins (1921) and later detailed in a model of primary succession in wetlands of the NSW central coast by Pidgeon (1940). This model describes successive zones from the water's edge of mangroves, which colonise mudflats as soon as they reach above low-tide level, saltmarsh, rushes and sedges, and finally casuarinas and melaleucas. Clarke and Hannon (1967, 1969, 1970, 1971) described similar zonation in several study sites to the north and south of Sydney. Thus the 'natural' or historical pattern of wetland vegetation along the Parramatta River foreshores from the water is consistently taken to be the successive zones of Pigeon's (1940) model (Karsens 1986, DEP 1986c, Benson & Howell 1990, NSW Property Services Group 1992, Kachka 1993, EDAW and Environmental Partnership 1997).

Whilst this pattern can be found in many places along the NSW coast (Adam et al. 1988), it is not universal. Clarke and Hannon (1967) found distinct patterns of zonation in some localities around Sydney but no discernible pattern in others. Kratochvil et al. (1973) mapped wetland communities at Smiths Creek, a tributary of Broken Bay, which displayed great variation in species associations and community patterning with all three major community types, mangroves, saltmarsh and casuarinas along the water's edge. Extensive saltmarshes not associated with mangroves have been found fringing the southern part of Wallis Lake, near Forster on the NSW north coast (Adam et al. 1988). Maps of the distribution of mangroves and saltmarsh on the Parramatta River for 1945–53 (Moss 1987) show saltmarsh along the water's edge without a mangrove fringe in a number of locations from Homebush Bay upstream, as do Clarke and Benson's (1988) map of Homebush Bay for 1931. In examining the temporal aspects of Pidgeon's model using several lines of evidence, Mitchell and Adam (1989a) could not find evidence to support Pidgeon's model of saltmarsh succeeding mangroves in the Georges River and Botany Bay system.

There are limited studies for the period prior to the 1930s. Hamilton's (1919) study of mangroves and saltmarshes of the Sydney District, included specific examples from the Parramatta River such as in Iron Cove, Hen and Chicken Bay, Homebush Bay and Duck River, but there is little indication of the distribution and areal extent of these communities in these locations. Benson and Howell (1990) refer to limited primary source material in describing the foreshore wetlands of the Parramatta River as part of

a wider study of Sydney's former vegetation. Clarke and Benson (1988), in discussing 200 years of change at Homebush Bay, used descriptions of 1843 and 1919 and mapped 40 years of change from the aerial photos 1930–1970. However, they did not consider the impact of dredging activity from 1905–1917 (McLoughlin in press) in shaping Wentworth Bay and the intertidal zone of Wentworth Point.

Materials and methods

A broad array of materials and sources was searched for evidence on the nature of the foreshores and foreshore vegetation of the Parramatta River before 1940: written material (Table 1), pictorial material in paintings and drawings and photographs (Table 2), and cartographic evidence in maps, charts and plans (Table 3).

Items discussed below are referenced to the tables thus: (table no: item no).

The cartographic evidence of the late 19th century was determined to be particularly useful and the data from a series of plans was used to compile a single map of the distribution and extent of mudflats, mangroves and saltmarsh in the 1880s–90s.

Evidence formats — discussion

Written material describing the European settlement of Sydney, its environment and the native people over its first ten years from 1788 is relatively abundant. After this, material on the immediate environment of Sydney is limited until the 1820s when travellers began to arrive and record their experiences for publication in Europe. However, soils and farming land were of more immediate interest to the settlers and description of wetlands and foreshore vegetation is less frequently found.

Of the pictorial material available, Sydney's early landscape paintings and drawings provide a far more accurate portrayal of the nature of the landscape and its vegetation than traditional critical comment has acknowledged (McLoughlin 1999). They can thus be a valuable source of evidence, either in the absence of any other evidence, or to assist in substantiating material from other sources. However, production primarily as artworks for exhibition or commercial publication, rather than simple landscape records, may affect their credibility, particularly if they are the only source of evidence or if they conflict with other sources. From the 1870s black and white photographs also become available.

Several key locations or views were favoured by painters and photographers and these appear repeatedly through the period, providing some indications of change. At Parramatta one such location was in the vicinity of the wharf looking downstream around the bend in the river, often as far as the Female Orphan School perched high above the river. As a major feature in a commanding position, the Orphan School was frequently painted in its surrounding landscape and it was also used as a point from which take views. Further downstream, homes and other buildings (signs of development and progress) on the northern bank were also favoured subjects. These included 'Vineyard', later 'Subiaco' (between Vineyard and Subiaco Creeks), the home and brewery of James Squires (Putney), 'Cleves' (Putney), and the Asylum (Gladesville).

Table 1. Description of the Foreshore Vegetation of the Parramatta River, 1788–1933.

	Observation	Location	Year	Observer and Source
1	*...about 4 mile higher than where the ships lay, the country was open and improved the farther we went up & in most places not any underwood, grass very long.*	Upper harbour	1788	Lt. William Bradley, Bradley 1969, p. 75
2	*...along the bank the grass was tolerably rich and succulent, and in height nearly up to the middle, interspersed with a plant much resembling the indigo.*	Above Duck River	1788	Surgeon John White, White 1962, p. 127
3	*The banks of it were now pleasant, the trees immensely large, and at a considerable distance from each other; and the land around us flat and rather low, but well covered in the kind of grass just mentioned.*	Above Clay Cliff Creek	1788	Surgeon John White, White 1962, p. 128
4	*About two miles below this settlement, the harbour becomes quite narrow, being not more than ten or twelve yards across, and the banks are about six feet high: here the country has the appearance of a park. In rowing up this branch, we saw a flock of about thirty kangaroos or paderong, but they were only visible during their leaps, as the long grass hid them from our view...*	3–4 km down-stream from Parramatta	1790	Lt. Phillip Gidley King, King 1968, p. 402
5	*Went into the SW branch, found it terminate in snug Coves, surrounded with Mangroves, rather shoal water.*	harbour	1788	Lt. William Bradley, Bradley 1969, p. 76
6	*Those coves above where the ships lay were surrounded by Mangroves & had Mud flats at the bottom...*	Upper harbour	1788	Lt. William Bradley, Bradley 1969, p. 79
7	*For it is strikingly singular that three such noble harbours as Botany Bay, Port Jackson and Broken Bay, alike end in shallows and swamps filled with mangroves.*	harbour	1792	Lt. Watkin Tench, Tench 1961, p. 64
8	Description of romantic scenery along the river which included *mangrove avenues and picturesque rocks*	Parramatta River	1793	Thomas Watling, artist Watling 1979, p. 23–24
9	On a shooting expedition to 'the Flats': *We landed on some low land or swamp, every step we took was up to our ankles in water...we walked in this manner for some hours seeing amazing quantities of ducks &c...after walking some hours we came to a brush which with the greatest difficulty we got through...but also up to our ankles in mud every step...*	Homebush Bay	1793	Richard Atkins, Judge-Advocate, Atkins 1791–1810, p. 120–21
10	*I had hardly touched ground when I found two tetragonias and various other oraches, all edible ...Then I saw a lythrum, the three geraniums already mentioned, three new species of lobelia, the mangrove, three banksias, the casuarina and many other plants.*	S shore about 1/2 way to Parramatta	1793	Luis Nee, naturalist, Cavanilles 1990, p. 155
12	Discussion of usefulness for boat timbers of *mangrove which grows in the upper end of the Coves and swamps.*	harbour	1794	Daniel Paine, Paine 1983, p. 38
14	Reports on supply of fine timber and charcoal from a Government farm at Long Bottom (now Canada Bay), *as well as Mangroves used for the Stone masons and cutters mallets.*	Hen and Chicken Bay	1819	Major George Druitt, Ritchie 1971, p. 6
15	Report on possible crossings of the Parramatta River mentioning *the different Mangrove Swamps on the West Side of Hen and Chicken Bay.*	H. & C. Bay	1828	Major Thomas Mitchell, Mitchell 1828
16	Description of the Great North Road passing Hen and Chicken Bay: *Its shores are low with mangrove flats.*	H. & C. Bay	1832	James Raymond, Raymond 1966, p. 75

	Observation	Location	Year	Observer and Source
17	*One portion of our land at Homebush consisted of salt-water marshes, covered in high tides and producing immense quantities of samphire. ...the mangrove grew very luxuriantly on the brink of the salt-water all along the embankments* (of drains cut through the marshes)*...these belts of green skirting the water were of great value in our view, and the sailing boats which passed daily up the creek glancing behind and between the groups of mangroves...*	Homebush Bay, between Powells & Haslems Cks	1843	Louisa Meredith, Meredith 1973, p. 155
18	*...beautiful bays branch off to each side: the water-worn sandstone rock is covered with gnarled gum and grass trees* (lower reaches)*... further up, the river, becoming more narrow, winds a good deal, and here and there are to be seen neat cottages, or elegant villas, the gardens and orangeries sometimes extending to the waterside.*	Parramatta River	1850	John Henderson, Henderson 1851, p. 103
19	*There are two species belonging to the Corolliflorae which abound on the banks of the Parramatta River (Aegeciras fragrans* and *Avicennia tomentosa). ...Near these may be seen Myrsine variabilis.*	Parramatta River	1859	William Woolls, Woolls 1867 p. 6
20	Iron Cove Creek runs *south-west out of Long Cove, with mud flats and mangroves along one shore, and around the next point* (Rodd Point), *Iron Cove, a little semi-circular bay, also lined with mangroves at its head.*	Iron Cove	1898	McLaurin & Hunt, McLaurin & Hunt, p. 60
21	Two branches of Powells Creek cross the 'marsh' near Concord West railway station: *banks of the shallow waterways are lined with Mangroves which display a graduated reduction in development as the channels merge into the plain.*	Homebush Bay	1919	A.A. Hamilton, Hamilton 1919
22	*...the heads of the bays are more or less like Iron Cove, all mangrove swamps, and there are possibilities of reclamation and of conversion into useful areas, Canada Bay, Exile Bay, Majors Bay, Yaralla Bay.*	Lower river, southern bays	1933	Chairman, Reclamation Trust of NSW, Maritime Services Co-ordination Board 1933

Table 2. Paintings, drawings and photographs of the Parramatta River.

No	Year	Creator	Title	Format	Location	Picture Location
1	1788	William Bradley	*A View in upper part of Port Jackson; when the fish was shot.*	watercolour	Difficult to locate	William Bradley (1960) opp p. 120
2	1798	unknown	*Captain Waterhouse's house, Sidney, Vineyard, about 1798*	watercolour	East side Vineyard Creek	ML SSV1B/PARR/6
3	1807	Attributed to G.W. Evans	Parramatta	watercolour	From Parramatta wharf looking downstream	ML SV1B/PARR/9, McCormick (1987) Pl. 132
4	1809	Unknown	*The landing place at Parramatta Port Jackson*	watercolour	From Parramatta wharf looking downstream	ML PXD388 Vol. 3 f.5, McCormick (1987) Pl. 133
5	1824 –25	Joseph Lycett	*Kissing Point, NSW*	aquatint	From Uhrs Pt. downstream across Rocky Point on S, Kissing Pt. on N	Lycett (1825)

No	Year	Creator	Title	Format	Location	Picture Location
6	1824 -25	Joseph Lycett	*View of the Female Orphan School*	aquatint	From south bank slightly upstream (position of James Ruse Drive)	Lycett (1825)
7	1824 –25	Joseph Lycett	*View of a Residence near Parramatta the property of John McArthur Esq.*	aquatint	From the Orphan School looking SW across river to Elizabeth Farm	Lycett (1825)
8	1825	Augustus Earle	*The Female Orphan School, P'matta, NSW*	watercolour	Looking downstream past Orphan School on high bank.	NLA Image 08144, Collison (1986) p. 8
9	1825	Augustus Earle	*A View in Parramatta, NSW*	watercolour	Looking downstream from near wharf.	Views N.S. Wales ML ZPX D265
10	1835	T. Godfrey	*The Orphan School, Parramatta NSW*	drawing	From directly across river	ML, Collison (1986) p. 1
11	1835	Robert Russell	*Parramatta, 5th Dec 1835*	watercolour	Looking downstream from near wharf	NLA Image 8789
12	c. 1837	Conrad Martens	*Parramatta River*	painting	View upstream to Parramatta from Orphan School	Art Gallery of NSW
13	1838	Conrad Martens	*Parramatta*	painting	View upstream to Parramatta from Orphan School	Parramatta City Council (1950) p. 9
14	1838	Conrad Martens	*(View of Parramatta)*	watercolour	View upstream to Parramatta from Orphan School	ML ZDLPg 15, Ellis (1994) p. 152
15	1840	Unknown	*Orphan School Reach*	sepia ink drawing	Looking directly upstream past Orphan School from downstream on water	de Falbe (1988) p. 19
16	1840	Unknown	*Red Bank and Farm*	pencil drawing	From N bank across to mouth of Clay Cliff Creek	de Falbe (1988) p. 19
17	1840	Attributed to F. Montague	*Female Orphan School, Parramatta*	painting	Looking across river and downstream from S bank	Collison (1986) p. 11
18	1840	Henry C. Allport	*Cleves*	ink & watercolour	Northern shores at Putney from S shore, east side of Uhrs Point.	*Sketches in Sydney* ML ZPXD 86 f.17
19	1840	Henry C. Allport	*Cleves - Parramatta River*	ink	Northern shores at Putney from S shore, east side of Uhrs Point	*Sketches in Sydney ...* ML ZPXD 86 f.31
20	1847	Unknown	*Parramatta NSW*	watercolour	Looking down stream from near wharf	ML ZDL PXX39 f.14

No	Year	Creator	Title	Format	Location	Picture Location
21	1850s	Unknown	*Byrnes Bros' flour mill and the George St. Barracks in the 1850s*	?	Looking down stream from near windmill	Parramatta City Council (1950) p. 13.
22	1858	Henry G. Lloyd	*Parramatta, NSW*	watercolour	Looking up-stream from S bank near present Alfred Street	*Sketches of N.S. Wales*
23	1860	C.F. Terry	*Tarban Point*	lithograph	Looking up Parramatta River at mouth of Tarban Creek	NLA Image. 9146, Terry 1860
24	1860	C.F. Terry	*Lunatic Asylum*	lithograph	From south side on Great North Road, Concord, across to Gladesville	NLA Image 9145, Terry 1860
25	1860	C.F. Terry	*From Kissing Point*	lithograph	From Top Ryde across River to Uhrs Point, Brays Bay, Homebush Bay	NLA Image 9147, Terry 1860
26	1860	C.F. Terry	*Subiaco c. 1860*	lithograph	From S bank across River to Rydalmere.	NLA 9148, Terry 1860
27	1860	C.F. Terry	*Parramatta*	lithograph	Parramatta River, Parramatta	NLA 9149, Terry 1860
28	1867	G.P. Slade	*Parramatta River*	watercolour	-	NLA Image 7643
29	1870	GPO	*Subiaco, Parramatta River, near Parramatta*	B&W photo	From directly across river on Grand Ave.	ML GPO1: 06145
30	1870	GPO	*Byrnes' Mill on Parramatta River n the 1870s*	B&W photo	From the Orphan School fence looking upstream to Parramatta	ML GPO1: 06146
31	1870s ?	GPO	*Protestant Orphan School, Parramatta*	B&W photo	From across river downstream	ML GPO1: 06139
32	1870s	GPO	*View of Protestant Orphan School*	B&W photo	From directly across the river	ML GPO1: 06131,
33	1880	Gibbs Shallard & Co.	*Parramatta River near Ryde*	B&W photo	From Top Ryde across river to Uhrs Point Brays Bay Homebush Bay	Gibbs, Shallard & Co. (1880)
34	1880s	W. Clarsen	*Iron Cove*	lithograph	Looking across Rodd Island	NLA Image 20600
35	1881	?	*Iron Cove, 1881*	B&W photo	?	ML Small Picture File
36	1890	John Paine	*Iron Cove*	B&W photo	From Birkenhead Pt across bridge to Callan Park	MM 82\039\697
37	1892	Dept. of Public Works	*View at Long Cove, suction dredge at work reclaiming land*	B&W photo	Iron Cove	Public Works Dept. 1892 p. 139

No	Year	Creator	Title	Format	Location	Picture Location
38	1892	Dept. of Public Works	*View at Long Cove showing canal, floating and shore discharge pipes*	B&W photo	Iron Cove Hawthorne Canal	Public Works Dept. 1892 p. 141
39	1914	GPO	*Parramatta River view*	B&W photo	Possibly from Meadowbank Park (Ryde Bridge) upstream across Wentworth Pt.	ML GPO1: 17488
40	1914	GPO	*Parramatta River views: from Abbotsford*	B&W photo	Possibly at Quarantine Reserve on Hen & Chicken Bay	ML GPO1: 17483
41	1914	GPO	*Parramatta River view*	B&W photo	Possibly in a bay on the northern shores	ML GPO1: 17482
42	1927	Concord Council	*The swampy nature of the ground around Exile Bay before reclamation*	B&W photo	Part of Hen & Chicken Bay, Parramatta River	Coupe (1983) p. 170.
43	1928	Melvin C. Kent	*Homebush Bay*	B&W oblique aerial photo	Across Ryde Bridge, full view of Homebush Bay	ML GPO1: 24964
44	1928	Melvin C. Kent	*Parramatta River west of Ryde Railway Bridge*	B&W oblique aerial photo	From above river near Putney, across Ryde Bridge & Homebush Bay	ML GPO1: 24971
45	1928	SHT	*Parramatta River at Camellia, looking east*	B&W oblique aerial photo	-	ML GPO1: 24975
46	1930s	-	*Looking west over Parramatta*	B&W oblique aerial photo	From down-stream of wharf	MM 83\066\0359b
47	1932	Sydney Mail	*A Swamp calling for Reclamation*	`B&W photo	Across the head of Canada Bay from the southwest	Official Consultative Committee (1932) p. 33
48	1930s	-	*Looking east over Concord Golf Course*	B&W oblique aerial photo	Across golf course and head of Majors Bay now Majors Bay Reserve	MM 83\066\0504
49	1936	MWS&DB	*18" Submain crossing Major's Bay to P.S. No. 90 Concord.*	B&W photo	From west shore south of the main, east across head of Bay	Sydney Water Archives
50	1936	MWS&DB	*18" Submain crossing Major's Bay to P.S. No. 90 Concord.*	B&W photo	From grounds of 'Yaralla' north of the main looking south-east	Sydney Water Archives

Notes to Table 2.

GPO = Government Printing Office, ML = Mitchell Library, State Library of New South Wales, MM = Macleay Museum, University of Sydney, NLA = National Library of Australia, MWS&DB = Metropolitan Water Sewerage & Drainage Board, SHT = Sydney Harbour Trust

Mitchell Library GPO images and National Library images can be viewed online via the respective library websites.

Table 3. Maps, Charts and Plans of the Parramatta River.

No	Date	Title	Creator	Location/ Coverage	Source/Plan No.
1	1789	*Chart of the Coast between Botany Bay and Broken Bay*	John Hunter	Includes Hawkesbury Parramatta & Georges Rivers	Hunter (1968), opp. 160
2	1789	*Port Jackson, Chart 6*	William Bradley	Port Jackson, Middle Harbour, Lane Cove River, Parramatta River	Bradley (1969)
3	1789	*The Channel to Rose Hill, Chart 11*	William Bradley	Parramatta River, Homebush Bay, Duck R., Haslems Ck., Powells Ck.	Bradley (1969)
4	1828, Dec.	*Sketch of Part of the Parramatta River Showing the proposed Situations for a Punt near Kissing Point.*	T. Mitchell H.F. White, Darcy	Parramatta River, Hen & Chicken Bay, Brays Bay, Majors Bay	SR Map 3221 SR Map 3222 SR Map 3223
5	1833, June	*Sketch of the Parramatta River near Redbank*	Thomas Mitchell	Parramatta River, Rydalmere	CP NLD P.843a, SR Map 4903
6	1833, Dec.	*Survey of part of the Parramatta River*	Mathew Felton	Parramatta River, Rydalmere, Camellia	CP NLD P.843, SR Map 4902
7	1840	*Map of Port Jackson and the Parramatta River NSW*	Brownrigg & Meadows	Parramatta River, Homebush Bay, Duck River, Parramatta	ML ZM3811.15/ 1840/1
8	1842	*Plan of a Site for a Village at Longbottom*	Galloway	Hen & Chicken Bay, Parramatta R.	SR Map 3381
9	1845	*Proposed Road in Parish of Hunters Hill*	J.J. Galloway	Parramatta River	ML ZM3811. 1423/1845/1
10	1856	*Sketch shewing the unoccupied Land at Longbottom*	- -	Hen & Chicken Bay, Homebush Bay, Parramatta River, Longbottom	LA V & P 1863-64 (5), p. 668
11	1857	*Plan of 22 Villa Sites on the Three Brothers Point opposite Five Dock, Parramatta River.*	E.J.H. Knapp	Parramatta River, Henly	ML ZMZ811. 1421/1857/1
12	1867	*Survey of Mr B.C. Rodd's Water Frontage, Iron Cove*	W. Orr	Iron Cove, Rodd Point, Fivedock	CP C935-690
13	1867, Sept.	*Survey of Mr B.C. Rodd's Water Frontage to Hen & Chicken Bay in connection with his application to be allowed to reclaim.*	W. Orr	Hen & Chicken Bay, Parramatta River	CP C965-690
14	1881	*Permanent Harbour Survey Long Cove etc*	J. Deering	Iron Cove, Parramatta River	CP 105-574
15	?	*Tracing showing part of the Water Frontage of Hen & Chicken Bay at Longbottom, Parish of Concord, County of Cumberland*	-	Hen & Chicken Bay, Canada Bay	CP 141-574
16	1883?	*Plan showing the foreshores at Fivedock Bay, Parramatta River, Parish of Concord, County of Cumberland*	-	Parramatta River, Five Dock Bay, Chiswick	CP 196-574

No	Date	Title	Creator	Location/ Coverage	Source/Plan No.
17	1883, Aug.	*Tracing shewing High Water Mark Chiswick Estate, Fivedock Bay, Parramatta River, Parish of Concord, County of Cumberland*	John Deering	Parramatta River, Five Dock Bay Chiswick	CP 197-574
18	1884, Nov.	*Plan showing Portions of River Frontage and Mortlake Road, Parish of Concord, County of Cumberland*	William L. King	Parramatta River, Mortlake, Majors Bay	CP 174-574 (C39-440)
19	1888, Aug.	*Part of Hen & Chickens Bay, Parish of Concord, County of Cumberland, shewing Positions of High and Low Water Marks and Frontage Detail*	Walter Mills	Hen & Chicken Bay, Canada Bay	CP 71-440
20	1888 Oct.	*Plan shewing survey of Mean High, and Low Water Marks on the western side of Hen & Chicken Bay, Parish of Concord, County of Cumberland*	George Knibbs	Hen & Chicken Bay, Exile Bay, France Bay, Cabarita	CP 72-440
21	1891	*Parramatta River from Homebush Bay to Queens Wharf, Parramatta — Compiled*	-	Homebush Bay, Parramatta River	CP 567-3000
22	1892	*Port Jackson Harbour Frontage from Bedlam Wharf to Gladesville Wharf*	Francis J. Gregson	Parramatta River, Looking Glass Bay	CP 209-574
23	1892, May	*Plan showing an area proposed to be dedicated as a reserve in connection with the Yaralla Hospital, Parish of Concord, County of Cumberland*	Walter Mills	Brays Bay	CP 656-3000
24	1892	*Port Jackson Harbour Frontage Gladesville to Parramatta*	V. Stephen	Parramatta River, Glades & Morrisons Bays	CP 207-574
25	1893	*Mean High Water Mark Parramatta and Duck Rivers*	V. Stephen	Parramatta River, Duck River, Homebush Bay	CP 230-574
26	1893	*Plan of Homebush Bay*	-	Homebush Bay, Parramatta River	CP 2977-3000
27	1926, June	*Proposed Reclamation Iron Creek Bay, Long Cove*	-	Iron Creek, Iron Cove	SHT file 32/6782 (SR 13/13878)
28	1919	*Soundings, Newington Wharf to Parramatta Tramway Wharf*	-	Parramatta River from Duck River downstream	SHT file 32/2796 (SR 13/13860)
29	1925	*Newington Wharf to Silverwater Wharf, Parramatta River*	G. Hart	Parramatta River from Duck River downstream	SHT file 32/2796 (SR 13/13860)
30	1930	*Hydrographic Survey, Broadoaks Estate, Parramatta River*	G. Hart	30 & 31 together cover approx. 1 km downstream from Duck River	348[5] & 375[5] in SHT file 31/6911 (SR 13/13864)

Table 3. cont.

No	Date	Title	Creator	Location/ Coverage	Source/Plan No.
31	1931	*Hydrographic Survey, Parramatta River*	G. Hart	30 & 31 together cover approx. 1 km downstream from Duck River	348[S] & 375[S] in SHT file 31/6911 (SR 13/13864)
32	1938	*Plan showing Hydrographic Survey between Charles St. Parramatta and Duck River, Parramatta River*	MSB	Parramatta River	Sydney Ports Authority, Roll 25 Sh 1
33	1939	*Duck River, Granville*	Dorman	Duck River, Parramatta River, Redbank	CP 12044-3000

Notes: SR = State Records of New South Wales, CP = Crown Plan, ML = Mitchell Library, State Library of New South Wales, LA V & P = Legislative Assembly (of NSW) *Votes and Proceedings*, SHT = Sydney Harbour Trust, MSB = Maritime Services Board of NSW.

Original Crown Plans are held by the Department of Land and Water Conservation (unless shown as SR Map), microfilm copies by the Registrar-General's Office.

Early pictures of the lower portions of the river and its bays are limited. Artists focussed on the main settlements and their settings — Sydney Cove and the surrounding harbour, and Parramatta. Up to the 1870s images are predominantly of the upper river, after the 1880s they are predominantly of the lower river.

Presence or absence of mangroves, specifically the Grey Mangrove, *Avicennia marina* (L.) Blanco, which forms pure stands, is the most easily identified feature of foreshore wetland vegetation in pictures. Not only is their location on the edge of the water a key indicator, but mangroves have a distinct dense rounded canopy which generally reaches ground/water level on the outer edges of a line or cluster of the trees. Eucalypts and casuarinas (specifically Swamp Oak, *Casuarina glauca*) also have distinctive forms, but different from mangroves. Low green areas are more problematic and may be saltmarsh or cleared grassed areas above high tide. Mudflats may be shown, but their absence may simply mean the picture depicts high tide.

Maps and plans can provide detailed and accurate information on the former distribution and extent of wetlands, especially larger scale survey plans. Maps of the Parramatta River commence with the charts drawn up by officers of the First Fleet, notably John Hunter and William Bradley. After Bradley, little of the inter-tidal zone of the Parramatta River was mapped until 1828 when a portion of the river between Brays Bay and Abbotsford was surveyed to fix a suitable crossing point (3:4). Prior to the 1860s, minimal vegetation, soils and topographic information was marked on surveys or on portion plans (surveys of individual parcels of land to be alienated from the Crown by grant or sale) but in 1864 Crown surveyors were directed to include this information (Jeans 1978). Surveys taken later in the 19th century can thus provide a detailed snapshot of a period 40–50 years prior to aerial photographs.

The most significant cartographic evidence of the former extent of mudflats, mangroves and saltmarsh in the Parramatta River derive from a series of surveys of the 1880s and 1890s (3:14–26). As dredging and the demand for reclamation of mudflats gathered pace (McLoughlin in press), there was a need to survey the harbour

foreshores to establish the line of high and low water marks and limit lines for reclamation. Plans 14, 22, 24 and 25 were part of this effort and were produced at large scale (one chain to the inch, 1: 792, or two chains to the inch, 1: 1584), on a series of large sheets. There is complete and detailed mapping of the northern foreshores from Bedlam Point (Gladesville) to Parramatta wharf and on the southern shores from Rhodes to Parramatta Wharf. On the south side downstream from Rhodes, with the exception of Iron Cove, surveys accessed for this paper are at similar scales but are less complete and evidence relies more on the inclusion of vegetation and other foreshore detail on waterfront property or other surveys (3:15–20).

Results

Lower River to Uhrs Point

From written descriptions it is evident that mangroves formed at least a part of the foreshore vegetation of the lower Parramatta River at the time of European settlement but it is not clear how extensive they were. Many references are general, or are not accompanied by precise location information. The earliest descriptions, from Bradley (1969), Tench (1961) and Paine (1983) (1:5, 6, 7, 12) indicate mangroves were clustered in coves at the heads of the bays on the southern shores. These bays were described as terminating or ending in 'snug coves' or shallows filled with mangroves. At that time bays were more indented than they are now, with a series of coves or minor embayments at tributary creeks (now walled and filled creating smoothly curved shoreline profiles). As the first surveys of the harbour were done from the water, the area of mangroves behind the shoreline fringe is not indicated. A description of the harbour 'ending' in 'shallows and swamps filled with mangroves (1:7) has been applied to upper river (Clarke & Benson 1988), but is more likely to describe the river at Homebush Bay. It is clear from a number of accounts (Bradley 1969, Phillip 1978, Paine 1983) that 'the Flats', the extensive intertidal mudflats and limited channels upstream from Uhrs Point (Fig. 2), were regarded as the head of the harbour.

The earliest painting of the lower river is by Bradley in 1788 (2:1), predominantly of rocky shoreline, but in the curves of two bays, or coves, bands of brighter green along the shoreline are likely to represent belts of mangroves. Although downstream from Uhrs Point, it is difficult to identify just where this picture is located, particularly given Bradley's tendency to exaggerate the vertical scale in rocks and cliffs, but it confirms his description of coves terminating in mangroves.

There are conflicting accounts of vegetation at the spot where two convicts cutting rushes (for roof thatching) were killed by Aborigines 'up the harbour', i.e. upstream from Sydney Cove, in 1788 (Hunter 1968, Tench 1961, Bradley 1969, White 1962, and Worgan 1978). A few miles by boat away from the settlement (Worgan 1978), in the 'southwest arm' (Bradley 1969), they were variously said to be found dead in the rushes or one or both in mangroves, but this incident indicates both mangroves and rushes (or reeds) were present, probably at the waters edge accessed by boat. An expedition by naturalist Luis Nee also indicates some variety in vegetation found on,

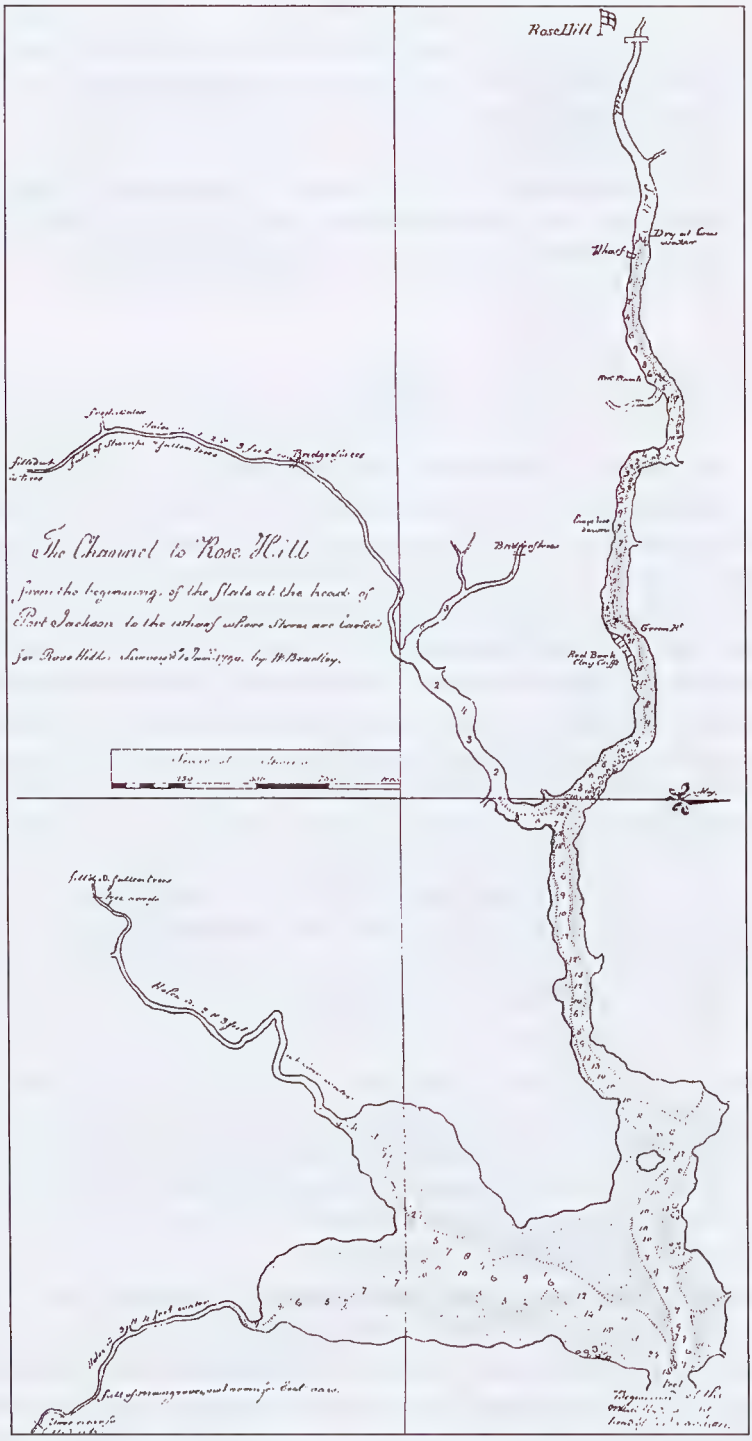


Fig. 2. William Bradley, A Voyage to New South Wales 1786–1792, Chart 11 'The Channel to Rose Hill from the beginning of the flats at the head of Port Jackson to the wharf where the stores are landed for Rose Hill'. Homebush Bay, Duck River and Upper Parramatta River to Parramatta (Rosehill) wharf. (Mitchell Library, State Library of New South Wales)

or near, the water's edge, including the wetland species–mangrove, casuarina and tetragonia (1:10).

In the 1820s and 1830s there is consistent evidence for the presence of patches of mangroves in Hen and Chicken Bay, both written (1:14–16) and in plans. Three versions of the 1828 survey of the river between Brays Bay and Abbotsford to fix a suitable crossing point (3:4) show patches of mangroves in Majors and Yaralla Bays and in two coves in the south and east parts of the head of Hen and Chicken Bay. The consistent orientation of the mangrove patches to the south and south-east of the bays and coves is striking, as are the presence of large inter-tidal zones not covered by mangroves. While the compiled map of the 1880s–90s surveys (Fig. 3a) is incomplete in its coverage of the shoreline, it confirms the patchiness of mangrove presence, their orientation to the southeast corners of the coves and the presence of large areas of inter-tidal mudflats in the southern bays of the lower river. By the 1930s, there were still large areas of saltmarsh and saltpan above normal high tide in Canada Bay (Longbottom) at the head of Hen and Chicken Bay (2:47) in the areas shown on Fig. 3a.

By 1927 a solid band of mangroves with an area of saltmarsh on the landward side was photographed in Exile Bay (part of Hen and Chicken Bay), prior to reclamation in the 1930s to create Edwards Park (2:42). In Majors Bay oblique angle aerial photographs of the 1920s show a large patch of mangroves is present covering most of the area to become Majors Bay Reserve (2:48). Ground photographs in 1936 (2:49–50) show most of these mangroves had been cut but were recolonising.

In Iron Cove an 1890 photo of Iron Cove Bridge from the north-east (2:36) includes the area of Callan Park which was to be reclaimed in 1893–94 (Public Works Department, 1893). Mangroves are not visible in this area in this photograph and the 1881 survey indicates the area was mudflats (Fig. 3a). Images of other parts of Iron Cove show the foreshores as cleared or open and grassy to the water's edge with scattered eucalypts and casuarinas (2:34, 35, 37). At the head of the bay change can be traced from 1881, when no mangroves are shown in Iron Creek (3:14, Fig. 3a). By 1898 mangroves are described as present on one bank (1:20) and by 1926 a large stand occupies half of the 1881 mudflats (3:27).

Further up river, Joseph Lycett's 1820s view of both banks from the vicinity of the present Ryde Bridge (2:5) gives no indication of mangroves, even around those points on the south side, now lined by this species. By the 1890s (Fig. 3a) the steeper rocky northern shores of the river had several generally very small patches of mangroves on mixed mud and sandy flats which were accumulating in bays and on parts of the shoreline. Hamilton (1919) notes saltmarsh fronted by a sandy shore at Meadowbank.

Brays Bay appears in 2:25 and 33, These broad views lack detail but it is still apparent that the part of Brays Bay within the view carries few if any mangroves, nor does the long foreshore of the Rhodes peninsula. Hamilton (1919) describes *Acacia falcata* lining the banks of Brays Bay and also notes the presence of a *Casuarina glauca* forest.

Fig. 3a. Composite map of wetlands of the Parramatta River in the 1880s and 1890s: Iron Cove to Meadowbank Railway Bridge, Charity Point. Compiled from Plans 14–20, 22–24 (Table 2). Some vegetation detail from Plan 12 also included. Dashed line indicates parts of shoreline for which no plan found showing wetlands in this period. Lack of a solid line boundary to wetlands reflects lack of a boundary on some plans where the inter-tidal zone was shown as context for the main purpose of the plan and their full extent was not surveyed.

Homebush Bay to Duck River

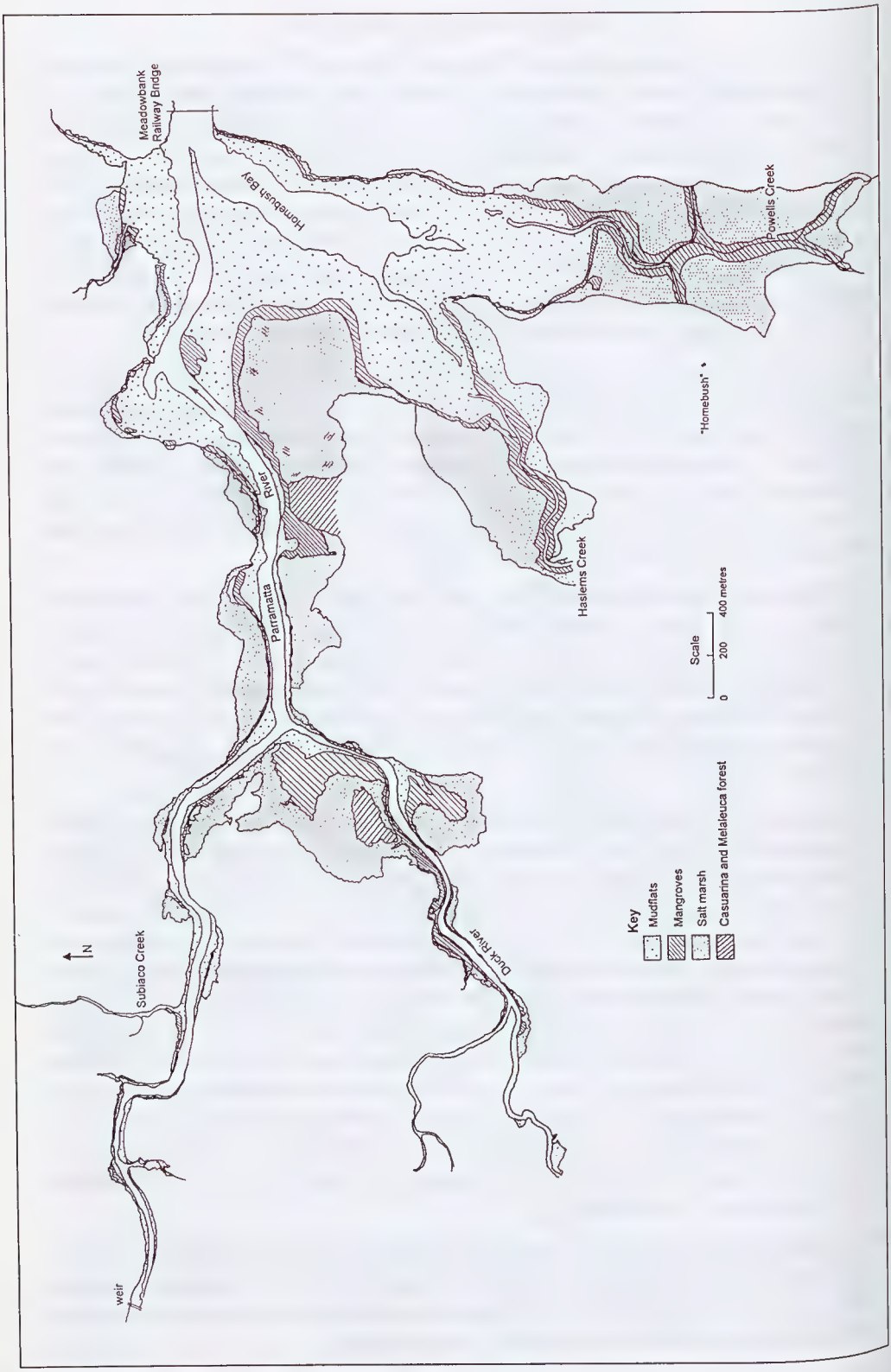
On Bradley's 1789 chart from Charity Point to Parramatta (3: 3, Fig. 2) both Homebush Bay and the river upstream are shown as predominantly consisting of inter-tidal areas cut by narrow navigable channels generally 2–3m deep. The 'Flats' could have been mudflats or saltmarsh but the stippled area on Bradleys chart did not carry mangroves — a mangrove island mentioned in his journal is delimited separately. 100 years later, a map compiled in 1891 (3:21) confirmed much of the topographic detail of Bradley's chart. Bradley's stippled areas were in fact extensive areas of mudflats and were still mudflats in 1891 (Fig. 3b) although the mudflats at the mouths of Haslams and Powells Creeks had prograded 190 m out into the Bay, presumably as a result of a century of clearing in the catchment and accelerated siltation.

In 1793 Atkins (1:9) appears to have spent hours tramping across saltmarsh at Homebush Bay before trying to get through a mangrove or casuarina/melaleuca thicket. Louisa Meredith (1:17) describes mangroves along the creeks and embankments of drains cut through the saltmarsh of Homebush Bay by the 1840s but on Powells Creek mangroves appear to have been discontinuous and there is no reference to large clusters of mangroves at Homebush Bay. Hamilton similarly describes mangroves lining channels at Homebush Bay in 1919 (1:21).

Confirming aspects of these earlier accounts, the plans of the 1890s (Fig. 3b) provide evidence of very extensive saltmarshes and mudflats from Homebush Bay to Duck River. Although there were several large patches of mangroves on Duck River and at Newington, mangroves were mainly restricted to fringes, generally narrow or in patches. There were also some large stands of *Casuarina* and *Melaleuca* forest. Both mangroves and casuarinas were found in small patches through the saltmarsh east of Newington.

Comparison of Fig. 3b with Clarke and Benson's (1988) maps from aerial photographs demonstrate the distribution of mangroves and saltmarsh on Haslams and Powells Creeks changed little between 1890 and 1930 except for the drainage channels east of the 'Homebush' residence, which no longer appear to be present in 1930. However there are dramatic changes in the wetlands of Wentworth Point on the western side of the bay with most of the former mudflat colonised by both saltmarsh and mangroves. Construction of seawalls in the early 1890s along the western shore of the bay and around the point, followed by dredging and reclamation 1905–1917, substantially altered the topography and inter-tidal zone of the enclosed area. Pumping dredged sediment onto this area, or diverting sediment deposition, may have enabled the expansion of mangroves and saltmarsh apparent by 1930 by sufficiently raising the level of parts of this inter-tidal mudflat. From the 1940s the area of saltmarsh and mangroves progressively declined as the major reclamation project of 1948–61 shaped the present form of Homebush Bay.

Seawalls were extended further upstream to Duck River on the south side by 1913 (Sydney Harbour Trust 1931). Surveys in the kilometre stretch downstream of Duck River between 1919 and 1931 (3:28–31) show a few patches of expanding mangroves on the south side as prograding mudflats are colonised.


Meadowbank Railway Bridge
Homebush Bay
Powells Creek
"Homebush"
Haslems Creek
Parramatta River
Scale
0 200 400 metres
Key
Mudflats
Mangroves
Salt marsh
Casuarina and Melaleuca forest
Duck River
Subiaco Creek
N
weir

There are few images of Homebush Bay, either paintings or photographs prior to the 1940s. In similar views across Rhodes peninsula and Homebush Bay from the high ridge above the river at Ryde in an 1860 painting (2:25) and an 1880 photograph (2:33) a dark band of mangroves is obvious along the shoreline of Homebush Bay, particularly in the 1880 photograph. Oblique angle aerial photographs of the river in the 1920s show extensive patches of mangroves in Homebush Bay and mangrove fringes along sections of the river banks upstream, although by no means continuous (2:43–46).

Upper Parramatta River above Duck River

In the narrow Upper Parramatta River, early descriptions give no hint of mangroves or other wetland vegetation, but rather of open banks and long grass (1:1–4). It would also not seem possible to see the houses and features mentioned by travellers as visible on a trip up the river in a small boat, if the river was lined with mangroves. These writers included Lt. King in 1790 (1:4), Peter Cunningham in the 1820s (1966) and John Henderson in the 1850s. The latter's description of the Parramatta River (1:18) contrasts markedly to his description of the Hunter estuary up river from Newcastle (150 km north of Sydney) where it begins to narrow and wind, 'the mangroves lining it to within the water's edge'.

Of 28 pictures (Table 2) created prior to 1870, 20 are of the river upstream from Subiaco Creek, Rydalmere. Only one shows vegetation that might be mangroves. Instead the banks are open to the waters edge with scattered or clumped eucalypts, casuarinas and other shrubs and small trees, or they are low cliffed banks about 2 m high (Fig. 4a) as King (1:4) described, in marked contrast to this stretch of river today (Fig. 4b).

The single painting (2:4) which possibly shows mangroves is so open to question that it cannot be taken as evidence without corroboration. Dated two years later than the very similar No. 3, small shrubs appear near the water on a bend on the northern bank downstream from Parramatta wharf. These shrubs are not present in No. 3 and could represent newly established mangrove seedlings. However, McCormick (1987) points out that other discrepancies between views 3 and 4 suggest that No. 4 was drawn from an 'earlier indistinct sketch'. In addition the shrubs are at some distance and not clearly depicted as in the intertidal zone, nor even on the water's edge. All other pictures of the same bend in the river have no mangroves present.

The pictures of and from, the Female Orphan School comprise the most consistent series anywhere on the river, depicting changes through to the 1870s. From the earliest views after its completion in 1818 the steep slope to the river in front of the school is open and grassed. But along the waters edge a narrow flat supports a continuous

Fig. 3b. Composite map of wetlands of the Parramatta River in the 1880s and 1890s: Homebush Bay to Parramatta wharf. Sources: Plan 21 (Table 2) — detail for much of Homebush Bay and for mudflats on most of map, Plan 25 — most of the saltmarsh and mangrove distribution, except west and south of Homebush Bay. Dated 1891 and 1893, the vegetation distribution on these two plans has a high level of agreement, except south of Haslams Creek where the zone beyond the mangroves is shown as 'salt swamp' on Plan 25, 'clay flat with mangroves in patches' on Plan 21. Density of shading for this area lies between mudflat and saltmarsh due to this discrepancy in the sources.

Fig. 4a. Parramatta c. 1837, Conrad Martens (The Clyde Bank Collection, Sydney). View upstream to Parramatta from Vineyard Creek. James Ruse Drive now crosses just beyond the boatshed on the water's edge. The entrance to Clay Cliff Creek, which winds up past Elizabeth Farm, is visible at left.

Fig. 4b. Parramatta River, 1999. View upstream from James Ruse Drive bridge over the river, of the same stretch of river as depicted in Fig. 4a. The entrance to Clay Cliff Creek is visible on the left.

Fig. 5a. View of the Female Orphan School, Joseph Lycett, 1824 (Lycett 1824–5, Mitchell Library, State Library of New South Wales). Despite Lycett's stylised portrayal of landscape and vegetation, this image, along with others of both banks of this stretch of river listed in Table 2 (Nos 6–8, 10, 12–17) depicts a shoreline vegetation of a diversity of eucalypt, casuarina and shrub species.

Fig. 5b. View of Protestant Orphan School, 1870s (Mitchell Library, State Library of New South Wales, GPO 1-06131). A young mangrove grows on the accreting mud along the foreshore in front of the Orphan School. This shoreline now has a complete fringe of tall mangroves. The Orphan School boatshed (in Fig. 4a) and elements of the former foreshore vegetation survive behind this fringe.

fringe of eucalypts, casuarinas and shrub species (Fig. 5a). Later pictures variously show the fringe as clumps and scattered trees (2:8, 10, 17) or relatively unbroken (2:15, 32). By about 1850, accumulation of sediment along the banks is obvious (2:17, 31) and in the 1870s an early photograph clearly shows a single young mangrove in the intertidal zone in front of the band of eucalypts and other terrestrial species (2:32, Fig. 5b). Today elements of the former waterfront fringe of terrestrial species still stand behind a tall belt of mangroves.

Discussion

Vegetation at the time of settlement

The combined written, pictorial and cartographic evidence builds a substantial, although incomplete, picture of the foreshores of the Parramatta River in the early years of settlement. Along the northern sandstone shoreline from Greenwich to Charity Point (and on the sandstone parts of the southern shores) rock outcrops and platforms were interspersed with sandy beaches (3:11, Campbell 1919, Cunningham 1966), backed by *Casuarina glauca* and moderate to steep slopes of sandstone eucalypt woodland. In the small narrow bayheads tributary creeks had built pockets of alluvium, beaches, limited mudflats and small areas of saltmarsh, reeds and rushes but few, if any, mangroves. On the south side from Balmain to Uhrs Point in the coves around the large embayments draining a largely shale catchment, were significant areas of intertidal mudflats and of low-lying alluvium covered in saltmarsh communities. There were patches of mangroves, particularly in the southeast of the coves and/or fringing the creeks but they did not form a consistent outer zone to saltmarsh.

From Homebush Bay upstream past Duck River erosion of the Wianamatta Shale had created broad areas of low-lying land, much of which flooded on spring high tides, and, like the southern bays downstream, large areas of inter-tidal mudflats not colonised by either mangroves or saltmarsh. Vegetation on the low-lying alluvium was dominated by extensive saltmarsh communities. Mangroves were present, at least along the Homebush Bay tributaries and on an island surrounded by mudflats (now part of the shoreline upstream of Wentworth Point) but there is insufficient evidence to determine their distribution at this time as far as Subiaco Creek. On slightly higher parts of the alluvium were groves of 'casuarina' and 'melaleuca scrub'.

Upstream from Subiaco Creek there is no evidence of mangroves in the early years of the colony. Here evidence indicates open eucalypt woodland with grassed understorey and well-spaced trees on raised alluvial banks, or mixed casuarina and eucalypt woodland with shrub understorey closer to the water's edge. Colonisation by mangroves appears to have begun in this part of the river in the latter part of the 19th century.

Post-settlement changes

Settlement along the river commenced at Parramatta in November 1788, Impacts included increased sedimentation, increased turbidity and changes in water quality with increased nutrient loading and other forms of pollution. As these accelerated, the wetland systems responded. Mudflats expanded in bays and along the margins of the river and by the late 19th century, mudflats were a dominant component of the inter-tidal zone (Figs 3a and 3b), along with saltmarsh.

Mangroves colonised upstream along shoreline not previously colonised, out onto mudflats and landwards into saltmarsh. There is evidence of mangroves beginning to appear in the upper river in the 1870s (Fig. 5b) and by the 1890s significant patches were established upstream from Duck River (Fig. 3b). By the 1930s mangroves in the southern bays were being targeted by local councils for reclamation (1:22). The Reclamation Act 1930 set up mechanisms by which reclamation could be approved, funded and the resulting land legally disposed. Recording of subsequent reclamation thus often describes areas reclaimed as mangrove swamps but the inference that mangroves were the pre-European vegetation, which remained intact until they were destroyed by reclamation, is a simplistic view of post-1788 impacts on these wetland systems. Using aerial photographs, Thorogood (1985) demonstrated that expansion of total mangrove area in Port Jackson-Parramatta River continued up until the 1950s with a 20% increase from 1930 to 1951, despite reclamations during this period.

Figs 3a and 3b show wetland vegetation 40–50 years earlier than previous mapping based on aerial photographs from the 1930s–40s. Whilst this cartographic evidence of wetland distribution is the most concrete and detailed available to date for the period prior to the 1930s, it represents only a snapshot in a possibly very dynamic system. However, there is some evidence, for example comparison of Figs 2 and 3b, that change in wetlands over the first 70–100 years may have occurred mainly as expansion of mudflats. Mangroves then expanded first onto mudflats and up river from the latter part of the 19th century (Fig. 3b) and into saltmarsh in the 20th century.

Although reclamation has been considered largely responsible for losses of extensive areas of wetland vegetation in most of the bays along the river (Lynch et al. 1976, Forbes and Shillington, 1987), comparison of Figs 3a and b with modern maps reveals that in many places the modern seawalled shoreline closely mirrors the low tide edge of the mudflats of the 1880s–90s. Areas filled were predominantly mudflats in the earlier reclamations of the late 19th and early 20th centuries. Later reclamations from the 1930s, such as at Hen and Chicken Bay, Homebush Bay and Duck River, affected large areas of saltmarsh. Mangroves were also affected but at least some of the mangroves destroyed during reclamation were of recent origin.

The mangrove referred to previously in this paper is the Grey Mangrove, *Avicennia marina*. *Aegiceras corniculatum* (Forsk.) Vierh., the River Mangrove was identified as abundant 'on the banks of the Parramatta River' in 1859 by William Woolls (1:19). However, of 25 specimens of *Aegiceras corniculatum* held by the National Herbarium of NSW, collected in the Sydney region from Broken Bay/Hawkesbury River to Port Hacking between 1887 and 1996, none are from the Parramatta River. Likewise, of

seven specimens held by the Royal Botanic Gardens, Kew, England, collected in the same region from 1862–1984, none are from the Parramatta River (R. Chinnock, Australian Botanical Liaison Officer, Kew, pers comm., 17 Sept. 1999). Both collections include a specimen collected in 1802–05 by Robert Brown from 'Port Jackson', at that time a general term for the entire Sydney settlement.

Only one of the studies or listings reviewed for this paper lists *Aegiceras* as present in the 20th century (Clarke & Benson 1988). Benson (pers. comm., 24 June 1999) states he saw one plant at Bicentennial Park, Homebush Bay which was later destroyed by boardwalk construction. It was not found by later Homebush Bay studies (Webster & Kachka 1992, Kachka 1993, M. Burchett, UTS Sydney, pers. comm. 26 July 1999) but has recently been located in a small cluster at Bicentennial Park (Swapan Paul, Scientific Officer, pers. comm. 4 Feb. 2000) and at Duck River (P. Adam, pers. comm. July 2000). Although not common, River Mangrove is specifically listed for nearby estuaries, Brisbane Water, Hawkesbury River, Pittwater, Botany Bay, Georges River and Port Hacking (West et al. 1985) and for Lane Cove River (Lane Cove Council 1998).

Mangroves, among other inter-tidal vegetation, were burnt for barilla, an alkaline ash used for soap manufacture in Australia from 1810 to about 1850. However, although there is evidence of harvesting mangroves at Hen and Chicken Bay for timber in the early 19th century (1:14), there is no evidence for other harvesting in the Parramatta River. Most of the soap factories were at Botany Bay (Bird 1981) and harvesting may have been focussed there. Harvesting is unlikely to have affected later distribution as *Avicennia marina* colonises and regenerates strongly in the Parramatta River (Clarke & Benson 1988).

Lack of available inter-tidal mudflats is unlikely to account for the apparent mangrove distribution at the time of European settlement, given the extent of open mudflats at Homebush Bay, for example, at this time. However, sedimentation along the banks of the upper river may have contributed to their expansion there by the late 19th–early 20th century. Increased nutrients from the effects of settlement: clearing, agriculture, domestic animals and urbanisation, may also have rendered some inter-tidal areas more suitable for mangrove colonisation than they had been prior to settlement (Saintilan & Williams 1999). Other changes in conditions possibly influencing the relative distribution of mangroves and saltmarsh in this system are a reduction in the freshwater component of the river towards Parramatta with the construction of the first weir there in 1857 (SMEC 1976) and reduced salinity in saltmarshes due to increased precipitation on the east coast of Australia since 1945 (Saintilan & Williams 1999).

Planning and conservation

Studies using the earliest aerial photographs as the primary information for the 'former extent' of wetland vegetation of the Parramatta River, may be fundamentally flawed if this is taken to represent distribution earlier than the 1930s–40s, given 140 years of change in the river system to that time. Planning studies which produce development controls or recommendations for enhancement of foreshore areas and

restoration of 'natural' vegetation communities based on a datum point in the 1940s may likewise suffer from erroneous assumptions.

The availability of aerial photographs, Lynch et al's (1976) unsourced statement and ecological inference regarding the historical distribution and nature of wetland systems of the Parramatta River have had a significant influence on foreshore planning and restoration activity. Mudflats, or gaps in the mangrove belt along the shoreline have been taken to mean that mangroves have been destroyed. New mangrove growth has been taken to indicate 'regenerating' mangroves (Register of the National Estate n.d. c, e, DEP 1986b, 1986c, Powell 1987, Gutteridge, Haskins & Davey 1991) and bare mudflats and gaps have been recommended for revegetation or regeneration with mangroves to restore the 'natural' foreshore vegetation (SPCC et al. 1983, DEP 1986d, Moss 1987, Clouston 1995, Pittendrigh, Shrinkfield, Bruce 1996, EDAW and Environmental Partnership 1997).

This examination of the available historical evidence indicates assumptions that Grey Mangrove, *Avicennia marina*, was a dominant component of the pre-settlement Parramatta River wetlands are not well-founded. Saltmarsh, including reed and rush communities, appears to have been more extensive and these communities have suffered the most severe reductions in area as a result of settlement (Thorogood 1985, Burchett & Pulkownik 1996). The casuarina/ melaleuca associations, although formerly perhaps less extensive than saltmarsh, have also become rare. By contrast mangroves expanded significantly onto rapidly expanding mudflats in the bays and up river from approximately the 1870s to the 1950s and into saltmarsh, at least from the 1930s (Clarke & Benson 1988), until reclamation impacted their area. A similar pattern of expansion has been described for the Lane Cove River (McLoughlin 1987).

Williams and Watford (1997) found expansion along the shoreline, downslope and upslope occurred from existing mangrove stands in Berowra and Marramarra Creeks, tributaries of the Hawkesbury River, between 1941 and 1992. Mangrove extension into saltmarsh in the Sydney region in the 20th century has also been noted in Botany Bay (Mitchell & Adam 1989), Hawkesbury River (Saintilan 1997), and the Hunter River (Buckney 1987). Further afield, studies using aerial photographs are demonstrating mangrove transgression in many coastal estuaries of south-eastern Australia over the last 50 years, but not in every estuary or in all creeks within an estuary (Saintilan & Williams 1999). However, discussion of the mechanisms causing mangrove expansion into saltmarsh is hampered by the relatively short time frame of the aerial photographs available.

Saltmarsh has been demonstrated to be important as bird habitat in the Hunter estuary (Buckney 1987) and Homebush Bay (Straw 1996) and mudflats in Homebush Bay and Hen and Chicken Bay (Taylor & Hutchings 1996). In the Parramatta River large numbers of ducks and other waterbirds were noted in the Homebush Bay/Newington area, where there were large areas of saltmarsh and mudflats, by Richard Atkins in the 1790s and Campbell (1919) and Garling (1924) in the 1850s. The listing of Parramatta River wetlands on the Register of the National Estate (n.d., a–g)) includes their important role as habitat for migratory birds covered under international agreements.

Clarke and Benson (1988) and Burchett and Pulkownik (1996) noted the significant loss of saltmarsh at Homebush Bay and Adam (1996) of saltmarsh in the Sydney region. Saintilan and Williams (1999) note its significant loss in other estuaries of the east coast. Recent conservation and rehabilitation work in the Homebush Bay and nearby Newington wetlands associated with the Olympic Games site, has focussed on monitoring and methods for saltmarsh re-establishment (Burchett & Pulkownik 1996), and Leichhardt Council (1999) has undertaken a small saltmarsh revegetation program at its Federal Park in Annandale. Elsewhere there has been little recognition of losses in saltmarsh along the river, and there is still little consideration or effort given to the replacement/replanting of saltmarsh, rush and reed communities while the focus remains on mangroves or while the perception that saltmarsh only existed in narrow bands behind mangroves persists (DEP 1986c). The more recent foreshores improvement plan for Duck River (EDAW 1997), which considers re-establishment of salt marshes as 'an appropriate conservation priority', is an exception.

Ongoing loss of saltmarsh also has significant implications for management of mangrove seedling invasion of the existing small saltmarsh zones in heavily impacted areas such as the Parramatta River. In many parts of Sydney *Pittosporum undulatum*, a species native to wetter bushland environments, is regularly culled from dry sclerophyll areas where absence of fire allows its invasion and expansion, threatening the viability of those communities. Should mangroves be similarly culled where they invade saltmarsh, under what conditions and in which areas?

This paper has brought together a variety of historical evidence to shed light on the nature of wetland distribution on the Parramatta River at the time of European settlement and subsequent changes up to the 1930s when aerial photography provides more consistent data. The study illustrates the importance of both location specific studies and the role of historical evidence in reconstructing the former distribution of vegetation to provide a firmer basis for conservation (Lunt 1998), management and, if appropriate, restoration.

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c) Meadow Bank Foreshore wetland, Meadowbank NSW, File No.019257.
d) Yaralla Bay wetlands, Concord West NSW, File No.019259.
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Surveys of areas having potentially high botanical diversity near Pooncarie, South Far Western Plains

AnneMarie Clements, Tony Rodd, Rosalind J. Moore, Adele G. Crane and John Simpson

Clements, AnneMarie, Rodd, Tony, Moore, Rosalind J., Crane, Adele G. (Anne Clements and Associates Pty Ltd, P.O. Box 1623, North Sydney, NSW Australia, 2059) and Simpson, John (RZM Pty Ltd, 250 St. Georges Terrace, Perth, W.A. Australia, 6000) 2000. Surveys of areas having potentially high botanical diversity near Pooncarie, South Far Western Plains. Cunninghamia *6(3): 611–643.* Vegetation in the remote Pooncarie region of south-western New South Wales was surveyed in the springs of 1995 and 1997 following rain. One area of 100 km^2 was examined in 1995 and three zones totalling 468 km^2 were surveyed in 1997. Sampling in 1997 targeted sites removed from artificial watering points and human habitation. Two of the three areas examined in 1997 were remote from access tracks. These areas were assumed to be relatively free from human impacts, have reduced grazing pressures and hence higher plant species diversity and a greater conservation value than areas which were closer to human disturbance or artificial water supplies.

Both the 1995 and 1997 data were statistically analysed using a hierarchical agglomerative clustering technique. Three broad vegetation groupings were discerned, Mallee dune crests, Lake beds and Mallee with *Trioda scariosa*.

Species richness for the area was high with 36% of the total species recorded being ephemerals. Exotic species were found in almost all the sampling locations, accounting for approximately 10% of the total species diversity. As exotic species are indicators of disturbance, it can be concluded that disturbance, or its influence, is widespread, but relatively minimal, throughout the area. Scats of native and exotic grazing animals were found throughout the survey areas.

A total of 375 species (328 native and 47 exotic) from 64 families/subfamilies was recorded in both surveys. In the 1995 survey, 263 species (226 native and 37 exotic) from 57 families/subfamilies were recorded. In the 1997 survey, 311 species (277 native and 34 exotic) from 61 families/subfamilies were noted. In terms of species of conservation significance, two species of national, five species of state and 21 species of regional significance were recorded. One new species was recorded for New South Wales and 25 new species were recorded for South Far West Plains botanical division.

Introduction

The vegetation of some of the most remote areas within the South Far Western Plains botanical division of New South Wales, east of the Darling River and west of Lakes Garnpung and Mungo (Fig. 1), was surveyed in the springs of 1995 and 1997 following rains. The November 1995 survey followed 52.6 mm of rain in October 1995. Prior to the September/October 1997 survey, 31 mm fell in August (Fig. 2). Wellard (1987) and

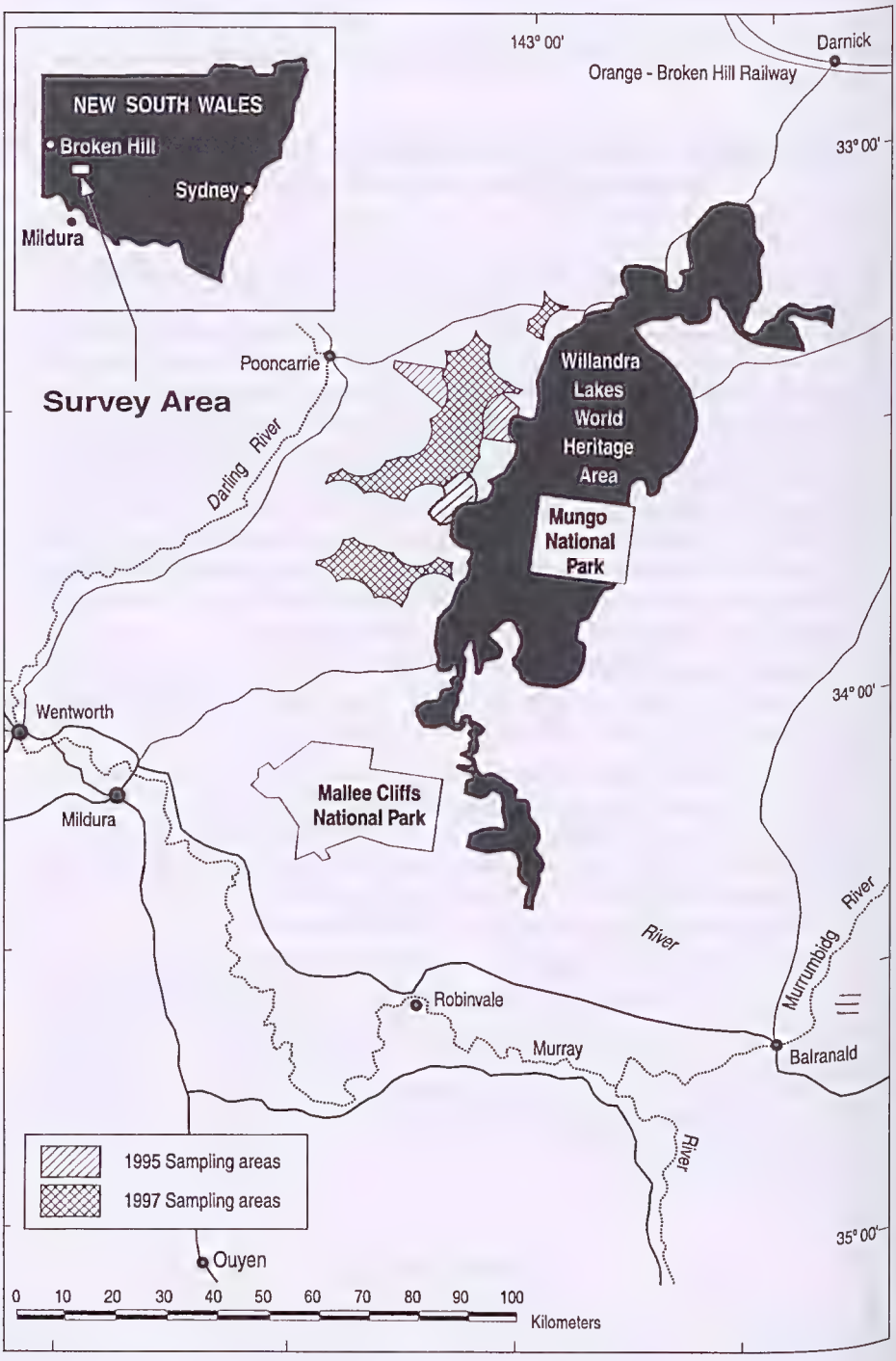

Fig. 1. Location map of 1995 and 1997 sampling areas.

Robertson (1987) found that rainfall in the previous six months explained 70% of the biomass variation in arid areas. In the repetitive sampling of mallee vegetation in western New South Wales from 100 m × 40 m quadrats, Fox (1990) found that both the number and composition of species recorded varied as a function of seasonal rainfall.

The initial survey in November 1995 was centred on an area surrounding 629000N 680000E (Australian Grid Map) covering about 100 km^2 on the western shore and parts of the dry lake bed of Lake Garnpung. There was minimal human impact and few artificial watering points in this area. The high species diversity and low weed occurrence were likely to be related to the relatively low intensity of grazing (Landsberg et al. 1997). Dr J. Landsberg, Wildlife and Ecology, CSIRO, Canberra and Professor T. Dawson, School of Biological Sciences, University of New South Wales (personal communication, March 1997) both estimated that feral goats had a grazing impact range of 5 km from watering points. In an attempt to survey ungrazed vegetation in the region, three areas, more than 5 km from artificial watering points, were targeted for investigation in the 1997 survey. These areas are within the Australian Map Grid rectangle 625000–632000N 640000–690000E (Fig. 3), at an elevation of approximately 70–120 m:

- Northern Area — 18 km^2 (631000N, 690000E) on Pan Ban and Garnpung Stations
- Central area — 300 km^2 (L-shaped 628000N, 647000–670000E; 628000–635000N, 670000E) on Lethero, Balranald Gate, Pt Balranald Gate, Birdwood, Yarraman and Garnpung Stations
- Southern area — 150 km^2 (626500N, 647000–670000E) on Studley, Lethero, Murragi, Petro and Arumpo Stations.

Climate

The climate of western NSW is semi-arid to arid. The features of the region are low, unreliable and highly variable rainfall, low humidity, high summer temperatures and evaporation rates, frequent dry periods lasting from several months to a number of years and occasional floods with rainfall occurring as intense storms (Date 1992).

In the study region, the average annual rainfall varies between recording stations within a narrow range of 234–275 mm, with a mean of 254 mm for ten stations in the vicinity. The average rainfall is uniformly distributed through the year with a 3% mean difference between summer and winter rainfall. Annual evaporation is about eight times the average rainfall (Dare-Edwards 1979).

Temperatures are consistently hot in summer and mild in winter (Date 1992). The monthly maximum temperature is 33.9°C in January and the monthly minimum is 4.7°C in July (Menindee Post Office meteorological station #047019) (Bureau of Meteorology 1988).

Soils

The 1995 survey sampled vegetation from six of the land systems described by Green (1980) in the Pooncarie 1: 250 000 sheet, namely: Arumpo Dunefields (Ap), Leaghur

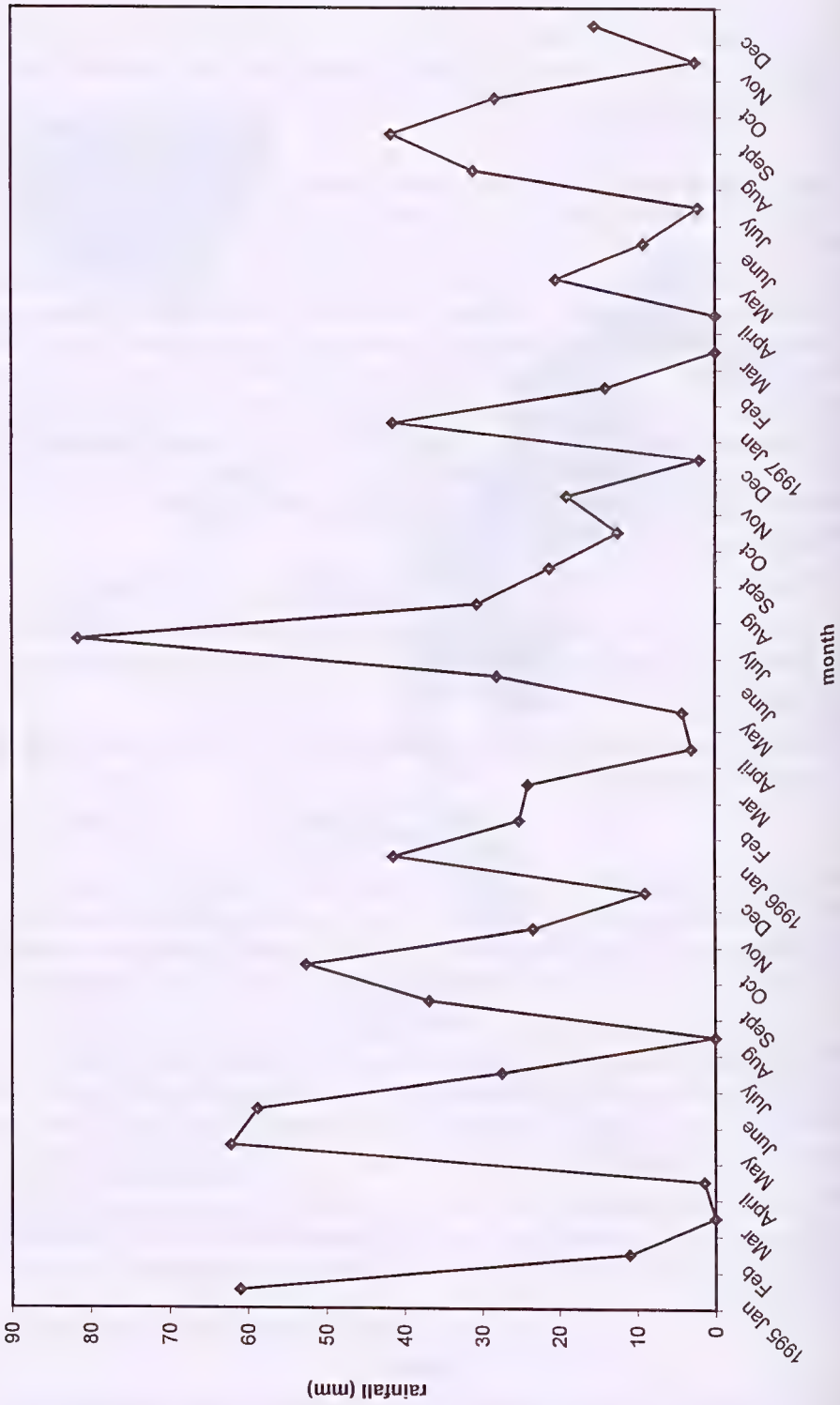

Fig. 2. Pooncarie: monthly precipitation January 1995–December 1997.

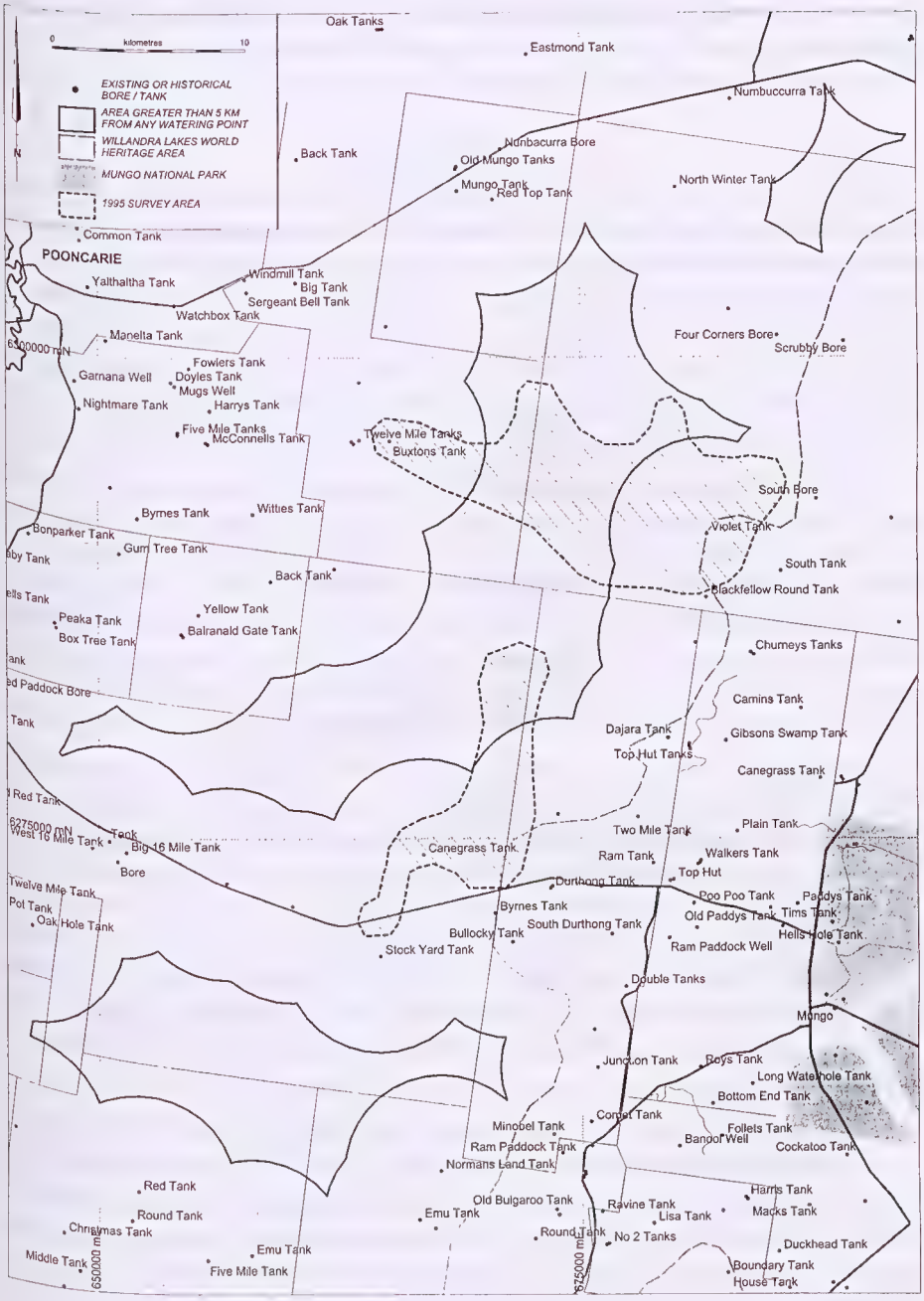

Fig. 3. Location of 1995 and 1997 survey areas in relation to artificial watering points.

Dunefields (Lh), Mandelman Dunefields (Mm), Overnewton Sandplains (Ov) and Garnpung Playas and Basins (Gn). The 1997 transect survey, although covering a greater area, only sampled flora from Ap, Mm and Mungo Playas and Basins (Mu) systems (Appendix 1). Leaghur Dunefields (Lh), Gn and Ov systems were sampled in spot surveys during 1997. Mandelman Dunefield is the only land system that occurred in both the 1995 and all 1997 survey areas.

Land use

The first wave of human occupation of the mallee lands of the South Far Western Plains Area dates from 50 000–40 000 years BP. Intervening arid phases with dune destabilisation and xeric conditions probably prevented any continuous occupation (Harris 1990). Evidence of ancient human occupation is found in the high shoreline gravels on Outer Arumpo and on the western side of all major lakes. In the dry lakes of the Willandra Creek system, there is evidence of a core and scraper industry associated with fires, burnt bones and unionid shells, coinciding with periods when lake water and aquatic life were present (17 000–32 000 years BP) (Bowler 1971).

In the 1870s, European occupation of the hinterland became possible with the introduction of well, bore and tank sinking techniques (Palmer 1991). Pastoral and agricultural activities introduced to the area expanded, leading to over-grazing, removal of vast areas of native vegetation and encroachment of exotic species of both fauna and flora (Webb 1998). The first reports of rabbit invasions occurred in 1884 concurrent with records of the proliferation of inedible native shrubs *Dodonaea* spp. (Hopbush), *Senna* spp. (Punty Bush) and *Eremophila sturtii* (Turpentine). Legislation in 1884 divided runs into term leasehold areas (Palmer 1991).

The 1901 New South Wales Royal Commission into the conditionof crown tenants in the Western Division of New South Wales listed seven principal factors contributing to widespread depression and general unprofitibility of the pastoral industry. The majority of these were based on the unsuitability of the environment for European farming practices, namely low rainfall, rabbit plagues, overstocking, sandstorms, growth of non-edible scrub, fall in prices and want of sufficient area (Noble 1997). Vast areas were windswept, with sand drifts covering fences, water troughs, stockyards and earthen dams. Extensive areas of perennial shrubs, notably the *Atriplex* spp. (Saltbush) and *Maireana* spp. (Bluebush), were destroyed, often on the more erodible soils (Palmer 1991).

Currently, grazing on uncleared land is the major land use. There are some short-rotation pastures and crops. These have varying success dependent on the erratic climate of the mallee land systems (Calder 1990). Condon (1986) suggested that there has been a major recovery since the 1940s and early 1950s with the frequency of these events having declined. He attributes this decline to the tight controls on land use in the Western Division of New South Wales exercised by the Western Lands Commission. Limitations are placed on the proportion, total area and pattern of clearing on any grazing leases. Restrictions on the clearing of sandhills have contributed to the relatively small proportion of mallee being cleared in the Western Division of New South Wales in recent years. The Western Division occupies an area

of 320 000 km^2. Budd et al. (1990) noted that of the 28 783 km^2 of mallee in New South Wales (Fitzpatrick 1982), 22 940 km^2 (80%) occur in the Western Division within the Murray Geological Basin. This represents approximately 7% of the area of the Western Division. The vast majority of this area is Crown Land, held under pastoral leases administered by the Department of Land and Water Conservation. In the mid to late 1980s approximately 8% of the Western Division was under the control of National Parks and Wildlife Service (Pickard 1987).

Previous flora surveys

One of the earliest surveys of the vegetation of south-western NSW (Turner 1904) describes the area between 141–147°E and between 33°S and the NSW-Victorian border. The current study area is located at approximately 143°E, 33.4°S. In Turner's accompanying tables, 147 members of the Compositae (family Asteraceae), including 23 exotics were listed.

The 1945 vegetation map (1: 1 000 000) of western NSW (Beadle 1948) is the most extensive representation of vegetation of the mallee areas of NSW. The vegetation communities identified by Beadle in the region were:

Atriplex vesicaria Association (Saltbush)

Kochia pyramidata (now *Maireana pyramidata*)-*Kochia sedifolia* (now *Maireana sedifolia*) Association (Bluebush)

Casuarina-Heterodendrum (now *Alectryon*) Association (Belah and Rosewood)

Eucalyptus oleosa-Eucalyptus dumosa Association (mallee)

Porteners and Ashby (1996) describe the vegetation of the Pooncarie 1:250 000 map sheet recording the vegetation communities, native plant species with descriptions of significant species and plant uses. For the Pooncarie 1: 250 000 sheet, Porteners et al. (1997) recognise 18 plant communities and record 330 species of vascular plants. Exotics accounted for 40 (12%) of the species. Their sampling sites were close to primary and secondary roads. The composition and extent of the present native vegetation was mapped from 1: 100 000 Landsat images and ground-truthed from 110 sites each of 1000 m^2 (50 m × 20 m). They noted that during their survey (May 1994 to April 1995) the region was undergoing a severe drought.

In the area covered by the 1995 survey, Porteners et al. (1997) identified five plant communities (Irregular Dune Mallee, Linear Dune Mallee, Belah-Rosewood, Belah-Rosewood/Lunette Shrubland and Open Area/Scattered Belah-Rosewood).

In the 1997 survey target areas, four plant communities were identified (Irregular Dune Mallee; Linear Dune Mallee; Belah-Rosewood and Black Bluebush/Disturbed Shrubland Complex).

The area of Irregular Dune Mallee (3a) south east of Pooncarie, extending over parts of Lethero, Petro and Arumpo Stations and known locally as 'No Man's Land' was identified as one of key conservation value (Porteners et al. 1997). This area was targeted in our 1997 survey.

In the 1: 250 000 land system mapping of the Western Division (Walker 1991), the vegetation was categorised into broad vegetation types, resulting in a vegetation map of low resolution (Fox 1984).

Mungo National Park, adjoining the study area, was surveyed by by Westbrooke and Miller (1995) in September 1992 following rain. Two hundred and thirty-five plant species were noted of which 26% were exotic. Morcom and Westbrooke (1990) mapped the vegetation of Mallee Cliffs National Park, located to the south of the study area (Fig. 1). They recognised 215 plant species, 20% of which were exotic.

Methods

In November 1995, the vegetation from 56 transects and 68 spot locations was surveyed. The majority of transects used in the 1995 survey were 100 m × 10 m, consisting of ten contiguous 10 m × 10 m quadrats. Transects 50, 54, 55 and 56 were all half this size, 50 m × 10 m (consisting of five 10 m × 10 m quadrats), the stands of homogeneous vegetation being of a smaller size at these locations. During the 1995 survey species-area curves were used to determine the minimum area required to adequately sample the vegetation. This area was found to be 500–600 m^2.

The relative frequency of plant species was objectively assessed by recording the presence/absence of each species in each of the contiguous 10 m × 10 m quadrats, though species not exceeding 2 m height were scored only for a 5 m × 5 m sub-quadrat in each quadrat. In each 10 m^2 quadrat, the numbers of individuals over 2 m high of each species were noted. In both surveys, transect sampling was supplemented by spot recordings.

Target areas for the 1997 survey were selected on the basis of being at a distance of over 5 km from known artificial watering points. The transect sampling area chosen was consistent with the 1000 m^2 sampling area size (50 m × 20 m) used in the 1: 250 000 Pooncarie sheet survey (Porteners et al. 1997). Transects of 100 m × 10 m were examined, homogeneity of vegetation recorded in the transects was assessed visually at the time of sampling, so that each transect should sample only one vegetation type. 'Spot' recording sites of 10 m radius (sampling area 300 m^2) were also examined.

In the 1997 survey, the methods were as used in 1995. Data from the northern, central and southern target areas were collected.

For the northern area, vegetation was sampled at a total of 27 locations, with 22 transects (57–66, 97–108) and five spot locations (A69, A79–A81 and A85). All spot locations and 20 of the 22 transects were within 1 km of the northern target area.

In the central area, vegetation was sampled from 44 sampling locations, with 30 transects (67–96) and 14 spot locations A70–A78, A82–A84, A86–A87). All but one of the transects and 11 of the spot locations were within 1 km of the central target area.

For the southern area 22 transects (109–130) and 40 spot locations (A88–A94, A96–A106, A109–A130) were surveyed. Spot locations A109–A130 were within 100 m of transects. Of the 62 locations, 19 transects and 30 spot locations were within 1 km of the southern target area.

Boundary and exploration tracks were used to identify exact locations during the 1995 survey. In 1997, sampling locations were recorded using a Garmin 38 GPS. In the northern and the central areas sampling was evenly spread over the area, whereas in the southern area, sampling was adjacent to access tracks. Sampling in the central area was limited to an individual land holding. Geographical co-ordinates for both the 1995 and 1997 transect and spot locations are shown in Appendix 1.

Due to the remoteness of the study area and small size of many of the plants to be identified, samples of all plants in each quadrat were collected and bagged separately, except for very common species which were collected at least once per transect. All bagged specimens were checked before data entry and any species of conservation significance sent to the Royal Botanic Gardens, Sydney for further confirmation. During 1997, in addition to the vegetation study, animal scats were collected from the transects. The scat data were supplemented by spot recordings allowing for an objective assessment of the presence of animal species.

Results

Flora observations

A total of 375 species (328 native and 47 exotic) were recorded in the 1995 and 1997 surveys. In the 1995 survey, 263 species (226 native and 37 exotic) were recorded. In 1995, the number of species per transect ranged from 21 (transect 34) to 57 (transects 1 and 21) (Appendix 1) with an average of 39 species of which 89% were native. Two transects recorded zero exotics.

Of the total 311 species (277 native, 34 exotic) recorded in the 1997 survey for the northern, central and southern areas, the following were observed in the individual areas:

Northern area: 167 species (145 native and 22 exotic). The number of species per transect ranged from 13 (transect 62) to 54 (transect 104) (Appendix 1) with an average of 33 species of which 31 (94%) were native. The transects with the greater number of species have the higher percentages of exotic species. In this relatively small area only two of the 22 transects had zero exotic species.

Central area: 218 species (199 native and 19 exotic). The number of species per transect ranged from 19 (transects 69 and 79) to 57 (transect 86) (Appendix 1) with an average of 34 species per transect of which 32 (95%) were natives. In 10 of the transects (33%), there were no exotic species recorded.

Southern area: 233 species (210 native and 23 exotic). The number of species per transect varied from 13 (transect 126) to 58 (transect 128) (Appendix 1) with an average of 33 species of which 31 (94%) were natives. No exotic species were recorded in 50% of the southern area transects.

The percentages of exotic species found in the 1997 survey were lower than those noted by Westbrooke and Miller (1995) in Mungo National Park (26%), and Morcom and Westbrooke (1990) in Mallee Cliffs National Park (20%), indicating that the remoteness of the 1997 target areas had aided the conservation of the indigenous flora.

Ephemerals

These are described in *Flora of New South Wales* (Harden 1990–1993) as annual herbs, except for a very few that are described as annual or perennial. In the arid western New South Wales environment, a species described as annual or perennial would most commonly behave as an annual. A total of 136 species of ephemerals was recorded in the 1995 and 1997 surveys (Appendix 2), accounting for 36% of the species. Of these 106 (78%) were native and 30 (22%) exotic. Ephemerals formed 36% of the total flora in both surveys. In 1995 there were 95 ephemeral species recorded, 22 (25%) of which were exotics. The 1997 survey recorded 112 ephemeral species, of these, 25 (22%) were exotic.

The number of ephemerals varied between the three 1997 survey areas (Appendix 2). In the northern and central areas compared with southern area there were higher percentages of ephemerals (47 and 42% compared with 37% respectively) and lower total numbers of species recorded (167 and 218 compared with 233 respectively).

Conservation significance

Communities

No Endangered Ecological Communities, as defined in the NSW *Threatened Species Conservation (TSC) Act 1995*, were noted in either the 1995 or 1997 surveys. Although there are existing mallee reserves in New South Wales, there has also been widespread retention of mallee on Crown Lands held as Western Lands Leases, in part to reduce the risk of dryland salinity and soil loss in agricultural areas (Brickhill 1988).

The *Eucalyptus socialis-Eucalyptus dumosa-Eucalyptus gracilis-Eucalyptus polybractea* mallee vegetation community is found in nine conservation reserves (Yathong, Nombinnie, Kajuligah, Round Hill, Tollingo and Loughnan Nature Reserves; Mallee Cliff, Mungo and Cocoparra National Parks), representing a large part of the range of the biogeographic regions in which the community occurs (Specht et al. 1995).

Species

In the 1995 survey, twelve species of conservation significance were recorded; one species at a national (ANZECC 1997, Briggs & Leigh 1996) and state (TSC Act 1995) level, namely *Brachycome papillosa*, one species, *Swainsona sericea* (formerly *Swainsona oroboides* subsp. *sericea*) under a state Vulnerable listing (TSC Act 1995) and twelve at a regional (Pressey et al. 1990) level: *Atriplex nummularia, Blennodia canescens, Boronia caerulescens, Brachycome papillosa, Calandrinia volubilis, Exocarpos sparteus, Grevillea pterosperma, Nicotiana occidentalis* subsp. *obliqua, Poa fax, Podotheca angustifolia, Sida* sp. aff. *corrugata* and *Swainsona sericea*.

Nineteen species of conservation significance were recorded in the 1997 survey, including one at national (ANZECC 1997, Briggs & Leigh 1996) level, namely *Lepidium monoplocoides*; four at state (TSC Act 1995) level namely: *Acacia acanthoclada, Lepidium monoplocoides, Santalum murrayanum* and *Swainsona sericea* and nineteen at a regional (Pressey et al. 1990) level, namely: *Acacia acanthoclada, Atriplex nummularia* (includes

Atriplex nummularia subsp. *omissa* in Harden (1990–1993)) *Atriplex vesicaria* subsp. *macrocystidia, Blennodia canescens, Boronia caerulescens, Calandrinia volubilis, Ceratogyne obinoides, Eucalyptus porosa, Exocarpos sparteus, Gahnia lanigera, Grevillea pterosperma, Lepidium monoplocoides, Menkea australis, Nicotiana occidentalis* subsp. *obliqua, Podotheca angustifolia, Santalum murrayanum, Sida* sp. aff. *corrugata, Swainsona sericea* and *Velleia arguta*. In the southern area twelve species of conservation significance were recorded, eleven species of conservation significance were recorded for the central area, and four species of conservation significance were recorded for the northern area (Table 1).

New records for New South Wales

No new records for New South Wales were noted in 1995. In the 1997 survey, one new record for New South Wales was found, namely *Lasiopetalum behrii*. A specimen has been lodged with the National Herbarium of NSW, Royal Botanic Gardens, Sydney.

Lasiopetalum behrii, a stiff-leaved shrub to 1.5 m high, flowering July to October (Jessop & Toelken 1986), was recorded at spot location A114 in the southern area in the 1997 survey. This species has been recorded by Willis (1973) for the region of north-western Victoria approximately north of Horsham and west of Swan Hill. Jessop and Toelken (1986) record *Lasiopetalum behrii* in the following botanical regions of South Australia: Flinders Ranges, Eyre Peninsula, Northern Lofty, Murray, York Peninsula, Southern Lofty, South Eastern and Kangaroo Island. These regions are all in the south-east quarter of that state.

Species not recorded by Porteners et al. (1997) and/or previously unrecorded for the South Far Western Plains botanical division

Our surveys found 74 species not listed by Porteners et al. (1997), doubtless a result of the better rainfall preceding our visits and the more extensive sampling of areas away from roads. In addition, 25 species not recorded by Harden (1990–1993) as occurring in the South Far Western Plains botanical division were noted (Table 2). Some species fell into both these categories, so that the total number of additional species records was 78.

Numerical analysis of the transect data

The combined data from 1995 and 1997 were numerically analysed using PATN (Belbin 1995). The transects were grouped using a hierarchical agglomerative clustering technique with a Bray-Curtis similarity measure of the abundance (0–10) of species within each transect. The estimate is based on the presence/absence of plant species in quadrats of the transects.

Three broad groupings were identified, namely:

Group 1 Mallee dune crests, mallee with *Callitris* spp. and lake shore with sand overblow (transects 9, 40, 42). This group was well represented in the 1995 survey area, with 22 of 56 transects. In the 1997 survey it occurred in the northern area (8 of 22 transects), in the central area (3 of 30 transects), but not in the southern area.

Table 1. Species of conservation significance recorded in 1995 and 1997 at the sampling locations

1995 : 1995 transects/points
N : northern 1997 transects/points
C : central 1997 transects/points
S : southern 1997 transects/points

Species	Location	National ANZECC (1997)	ROTAP (1996)	State TSC Act (1995)	Regional Pressey et al. (1990) category	priority
	S: 124, A96, A126	-	-	E	3B	4
Atriplex nummularia (includes *Atriplex nummularia* subsp. *omissa* in Harden 1990–1993)	1995: 11, 47 C: 78	-	-	-	3A	3
Atriplex vesicaria subsp. *macrocystidia*	C: 78 S: 128, 130, A105	-	-	-	4A	4
Blennodia canescens	1995: 6 N:58, 97	-	-	-	3B	4
Boronia caerulescens	1995: 7, 15, 26, 27 S: A88	-	-	-	3B	4
Brachycome papillosa	1995: A59, A60	V	3V	V	2	2
Calandrinia volubilis	1995: 11, 13, 28, 32, 54 C: 78 S: 130, A105	-	-	-	3A	3
Ceratogyne obinoides	C: 88 S: 110, 111, 113, A116	-	-	-	3B	4
Eucalyptus porosa	S: A92	-	-	-	3B	4
Exocarpos sparteus	1995: A10, C: 87, A77 N: 104	-	-	-	3B, 4A	4
Gahnia lanigera	S: 115, 116, 120	-	-	-	3B	4
Grevillea pterosperma	1995: 18, 36, 54 C: 67, 68, 79, A70 S: 121, 123, A120	-	-	-	3B	4
Lepidium monoplocoides	C: A82	E	3ECi	E	3A	2
Menkea australis	N: 61 C: 74, 75, 84 S: 113, 115, 117, 120, 123, 124, A116	-	-	-	3B	4
Nicotiana occidentalis subsp. obliqua	1995: 1, 4, 19, 21, 23, 27, 28, 29, 30, 32, 33, 39, 40,	-	-	-	3B	4

Species	Location	National ANZECC (1997)	ROTAP (1996)	State TSC Act (1995)	Regional Pressey et al. (1990) category	priority
	42, 44, 56, A1, A25, A30, A31, A33, A38, A40, A45, A48, A49, A62, A64, A65 C: 88, 94, A75 N: 66, 97, 98, 99, 107, A85 S: 110, 123, A110					
Poa fax	1995: 11, A58	-	-	-	3B	4
Podotheca angustifolia	1995: 14, 28, 29, 46, 49, 53, 54, A10, A41, A43, A51, A63 C: 87 S: 110, 111, 113	-	-	-	3B	4
Santalum murrayanum	N: 62	-	-	E	3B	4
Sida sp. aff. *corrugata*	1995: 3, 45 C: 89	-	-	-	3B	4
Swainsona sericea (formerly *Swainsona oroboides* subsp. *sericea*)	1995: 21, 35, A32, A34, A45 C: A75			V preliminary	4B	4
Velleia arguta	S: A106	-	-	-	3A	3

Key for Table:

National
ANZECC (1997)
E: endangered

ROTAP (Briggs & Leigh 1996)
3: distribution of >100 km
E: endangered
V: vulnerable
C: present in a conservation reserve
i: inadequately conserved

State
TSC Act (1995)
E: endangered
V: vulnerable

Regional
Pressey et al. (1990)
Categories
1 occurring only in the Western Division with a restricted distribution
3 restricted distribution in the western Division and also occurring interstate:
A: small range and/or few records interstat
B: wide range and/or many records interstate
4 disjunct occurrences in the Western Division
A: main population interstate
Priorities
1 protection measures in the Western Division will completely determine the survival of these taxa nationally
2 protection measures in the Western Division will be a very important contribution to conservation of the taxa throughout Australia
3 conservation of the species in the Western Division will influence its overall survival
4 protection in the Western Division is desirable to conserve genetic variation within the ranges of these taxa

Table 2. Species not recorded by Porteners et al. (1997) and/or not previously recorded for SFWP (South Far Western Plains) as listed in Harden (1990–1993)

New SFWP	Botanical name	When Found
Yes	*Acacia havilandiorum*	97
Yes	*Aira caryophyllea*	95, 97
-	*Amphipogon caricinus* var. *caricinus*	95, 97
Yes	*Amyema cambagei*	97
Yes	*Anagallis arvensis*	95, 97
-	*Angianthus tomentosus*	97
Yes	*Aotus subspinescens*	97
Yes	*Atriplex turbinata*	95
-	*Austrostipa mollis*	
	(formerly *Stipa mollis*)	95
Yes	*Austrostipa scabra* subsp. *scabra*	
	(formerly *Stipa scabra* subsp. *scabra*)	95, 97
Yes	*Austrostipa tuckeri*	
	(formerly *Stipa tuckeri*)	97
-	*Avena barbata*	95
-	*Bertya* sp.	95
Yes	*Beyeria leschenaultii*	95, 97
-	*Billardiera versicolor*	97
-	*Blennodia canescens*	95, 97
-	*Brachycome ciliaris* var. *lanuginosa*	95, 97
-	*Bulbine alata*	95
Yes	*Calandrinia granulifera*	97
-	*Calandrinia volubilis*	95, 97
-	*Carthamus lanatus*	95
-	*Centipeda thespidioides*	95
-	*Citrullus lanatus*	95
-	*Cressa cretica*	97
Yes	*Cryptandra amara* var. *floribunda*	95, 97
Yes	*Daviesia acicularis*	95, 97
-	*Einadia nutans* subsp. *oxycarpa*	95, 97
-	*Epaltes australis*	95
-	*Eragrostis dielsii*	95
-	*Erodium cygnorum* subsp. *glandulosum*	95, 97
-	*Frankenia serpyllifolia*	95
-	*Gahnia lanigera*	97
-	*Gnaphalium sphaericum*	95, 97
-	*Gnephosis eriocarpa*	95
-	*Goodenia glauca*	97
Yes	*Goodenia havilandii*	95, 97

New SFWP	Botanical name	When Found
Yes	*Gypsophila australis*	97
-	*Halosarcia pergranulata*	97
-	*Halosarcia* sp.	97
Yes	*Lasiopetalum behrii*	97
-	*Lemooria burkittii*	95, 97
-	*Lepidium monoplocoides*	97
-	*Lepidosperma* sp. aff. *viscidum*	97
-	*Limosella curdieana*	97
-	*Lomandra leucocephala* subsp. *leucocephala*	95, 97
-	*Lotus cruentus*	95
-	*Maireana pentagona*	95
-	*Menkea australis*	97
-	*Millotia tenuifolia* var. *tenuifolia*	97
-	*Myoporum platycarpum* subsp. *perbellum*	95
Yes	*Pentaschistis airoides*	97
-	*Plantago turrifera*	95, 97
-	*Poa fax*	95
-	*Pogonolepis muelleriana*	95, 97
-	*Polygonum aviculare*	95
-	*Pterostylis* sp. aff. *biseta*	97
Yes	*Ranunculus trilobus*	95
-	*Rhodanthe microglossa*	95
-	*Rhyncharrhena linearis*	95, 97
-	*Rutidosis helichrysoides*	95
Yes	*Sagina apetala*	97
-	*Scaevola spinescens*	97
-	*Senecio quadridentatus*	97
-	*Sida* sp. aff. *corrugata*	95, 97
Yes	*Silene nocturna*	97
-	*Stuartina hamata*	97
Yes	*Stuartina muelleri*	97
Yes	*Swainsona sericea*	95, 97
-	*Synaptantha tillaeacea*	97
-	*Thysanotus patersonii*	95, 97
-	*Tripogon loliiformis*	97
Yes	*Triptilodiscus pygmaeus*	95, 97
Yes	*Velleia arguta*	97
Yes	*Velleia paradoxa*	97
-	*Vittadinia condyloides*	95, 97
-	*Vittadinia eremaea*	95, 97
Yes	*Vittadinia sulcata*	95, 97

Group 2 Lake beds with *Casuarina pauper, Dodonaea viscosa* subsp. *angustissima, Alectryon oleifolius* subsp. *canescens,* herbfield, or *Atriplex vesicaria* subsp. *macrocystidea* shrubland; mallees without abundant *Triodia scariosa* and sometimes with *Casuarina pauper.* This group was represented in all survey areas with 13 of 56 transects in 1995 survey and 5 of 22 transects in the northern area, 12 of 30 transects in the central area, but only 2 transects in the southern area and 4 transects outside the southern target area in the 1997 survey.

Group 3 Mallee with abundant *Triodia scariosa.* This group was represented in all survey areas with 21 of 56 transects in the 1995 survey, 9 of 22 transects in the northern area, 15 of 30 transects in the central area, and 16 of 22 transects in the southern target area in the 1997 survey.

The grouping of individual transects is shown in Appendix 1.

Fauna observations

Investigations by Dawson and Ellis (1994) on open plains in far western New South Wales demonstrated that domestic sheep (*Ovis aries*) and red kangaroos (*Macropus rufus*) had considerable dietary overlap (87%) with grasses being the major component for both species. The diet of feral goats (*Capra hircus*) at Fowlers Gap Research Station (approximately 250 km north of the study area) was studied by Dawson and Ellis (1996). Fowlers Gap lies approximately 250 km north of the study site and has a diverse topography, the western portion includes part of the Barrier Ranges, whereas flood plains occur in the east. Goats have a broad diet with a preference for browsing, taxa consumed included *Acacia aneura* (Mulga), *Alectryon oleifolius* (Rosewood), *Canthium oleifolium* (Wild Lemon), *Casuarina pauper* (Belah) and *Myoporum platycarpum* (Sugarwood), eucalypts were not eaten.

Scats were collected at the time of the vegetation survey. At this time, there was standing water in many of the clay former lake beds. Grazing animals, especially kangaroos, were observed near standing water. Kangaroo scats were recorded in all transects where scats had been collected. Goats were the second most widespread of the animal species noted in the area. Goat scats were not recorded in:

- the central area in mallee with *Triodia* (transects 67, 69, 70, 79, 83, 84, 85) and former lake beds (transects 72, 78, 80, 81, 82, 86)
- the southern area in mallee with *Triodia* (transect 115) and former lake bed (transect 130).

Goats were recorded in all transects sampled in the northern area. Sheep were recorded once and possibly twice on four sampled transects in the northern area, four times in 20 sampled transects in the central area, and three times on 22 sampled transects in the southern area. Emus (*Dromaius novaehollandiae*) were recorded infrequently. Emus did not appear to discriminate in terms of vegetation structure and were noted on each of the three major vegetation groups (transects 71, 74, 129).

Rabbits were not recorded in the northern area. They were noted once in the central area (transect 71 in mallee with *Triodia*) and in 7 of the 22 transects in the southern area (five lake bed, and two mallee with *Triodia* transects). The scat collections appear to be

consistent with Dawson and Ellis (1996) at Fowlers Gap, namely that kangaroos can travel large distances from watering holes, goats are tolerant of the arid conditions and sheep are restricted. The fencing in the area may have limited the distribution of sheep, but it is more likely that the lack of water determined their distribution. The southern area contained the largest core area of undisturbed vegetation; observations of scat densities during surveys in the southern area indicated a marked decrease in goat presence at distances in excess of 8 km from water sources.

Conclusion

Surveys of the Pooncarie area were conducted in 1995 and 1997. An area centred at 629000N and 680000E was examined during 1995, whereas the 1997 survey targeted three zones that were selected to be more than 5 km from any artificial watering points. The areas surveyed, 100 km^2 (1995) and 468 km^2 (1997) were relatively remote from roads and human habitation. The surveys covered approximately 4% of the 15 180 km^2 mapped by Porteners et al. (1997). Porteners et al. (1997) reported nine species not previously recorded for the South Far Western Plains botanical subdivision of New South Wales, namely, *Abutilon fraseri*, *Amaranthus macrocarpus* var. *macrocarpus*, *Chamaesyce* species B, *Cheilanthes distans*, *Cheilanthes lasiophylla*, *Digitaria ammophila*, *Evolvulus alsinoides* var. *decumbens*, *Leptorhynchus panaetiodes* and *Sporobolus caroli*. None of these species was recorded in our 1995 and 1997 surveys. However, we noted 78 species that had not previously been recorded by Porteners et al. (1997) and/or recorded in the South Far Western Plains botanical division (Harden 1990–1993). There were 136 ephemeral species (95 in 1995 and 112 in 1997) recorded. Of these ephemerals, 30 (22%) were exotics. The timing of the Porteners et al. (1997) survey coincided with a drought, whereas the 1995 and 1997 surveys followed rain which would have encouraged the germination of ephemerals.

Despite the remoteness from artificial watering points, scats of native and exotic grazing animals were found in the 1997 survey areas. Kangaroo scats were recorded at all collection locations and goat scats were frequently observed. Animals were observed near the standing water that collected in the clay former lake beds after rain.

In the 1997 survey, the number of plant species recorded in the 300 km^2 central area (218 total, 199 native, 19 exotic) was similar to the number in the 150 km^2 southern area (233 total, 210 native, 23 exotic). The lower number of species recorded in the 18 km^2 northern area (167 total, 145 native, 22 exotic) is likely to be related to the smaller size of the sampling area (Fig. 2). Exotic plants were part of the flora assemblage in virtually all locations sampled. The presence of exotic seedlings, such as *Hypochoeris glabra*, indicates their very high wind-borne dispersal ability. In many communities, their seeds germinate after rain but the plants fail to establish in the longer term. The numbers of exotic species have been consistent between the 1995 survey (39 exotics) and the 1997 survey (34 exotics), also between the three target areas in 1997 (19–22 exotics). In 1995, 15% of the species noted were exotics. Exotics formed approximately 10% of the total species diversity in the 1997 surveys (13% in northern area, 9% in central and 10% in southern areas).

In terms of conservation significance, nineteen species of National, State and/or Regional level were recorded in the areas surveyed in 1997. Four species of significance were noted in the northern, 11 in the central and 12 in the southern area. In 1995, 12 species of conservation significance (National, State and/or Regional) were recorded. No Endangered Ecological Communities (TSC Act 1995) were noted.

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Appendix 1. Site locations and soil and vegetation descriptions for spots and transects

Soils as described by Green (1980):
Sandplains: Ov — Overnewton, Dunefield: Ap — Arumpo, Mm — Mandleman, Lh — Leaghur
Playas and Basins: Gn — Garnpung, Mu — Mungo
Vegetation as described by Porteners et al. (1997):
3a Irregular Dune Mallee, 3b Linear Dune Mallee, 3d Sandplain Mallee,
4 Belah-Rosewood, 8 Black Bluebush, 22 Disturbed Shrubland Complex, 30 Lunette Shrubland
OA Open Areas, C Cleared and/or cropped

Spots A1–A68: 1995
A69, A79–A81, A85: Northern 1997
A70–A78, A82–A84, A86–A87: Central 1997
A88–A94, A96–A106, A109–A130: Southern 1997

Spot	Spot locations		Vegetation	Soil	Total no.of species	Exotic species	Percent exotic species
	North	East					
A1	6294500N	674200E	3a	Ap	19	1	5
A2	6294300N	674300E	3a	Ap	1	0	0
A3	6294300N	674800E	3a	Ap	1	0	0
A4	6294100N	675300E	3a	Ap	1	0	0
A5	6294400N	675400E	3a	Ap	1	0	0
A6	6294300N	675800E	3a	Ap	7	0	0
A7	6294400N	676000E	3a	Ap	8	0	0
A8	6294200N	676250E	3a	Ap	16	0	0
A9	6294000N	676400E	3a	Ap	4	0	0
A10	6293800N	676700E	3a	Ap	5	0	0
A11	6294100N	677200E	3a	Ap	6	1	17
A12	6293800N	677400E	3a	Ap	14	1	7
A13	6293700N	678300E	3a	Ap	22	5	23
A14	6293700N	678700E	3a	Ap	10	1	10
A15	6293600N	679200E	3a	Ap	8	0	0
A16	6293800N	679600E	3a	Ap	1	0	0
A17	6293700N	680000E	3a	Ap	6	1	17

Spot	Spot locations North	East	Vegetation	Soil	Total no.of species	Exotic species	Percent exotic species
A18	6293300N	682100E	3a	Lh	9	0	0
A19	6292500N	683100E	3a	Gn	1	0	0
A20	6290600N	682700E	3a	Ap/Lh	12	3	25
A21	6290400N	682600E	3a	Ap/Lh	16	3	19
A22	6291400N	675600E	3a	Ap	3	0	0
A23	6290200N	682400E	3a	Ap	18	6	33
A24	6297800N	672600E	3a	Mm	1	0	0
A25	6297600N	672700E	3a	Mm	26	7	27
A26	6296800N	672400E	3a	Mm	2	0	0
A27	6290800N	673800E	3a	Ap	4	0	0
A28	6291250N	677300E	3a	Ap	22	3	14
A29	6295400N	679300E	3a	Ap	18	1	6
A30	6291000N	681000E	3a	Ap	10	1	10
A31	6290750N	681100E	3a	Ap	17	4	24
A32	6291000N	681500E	3a	Mm	45	16	36
A33	6290500N	681350E	3a	Ap	14	2	14
A34	6290000N	681900E	3a	Ap	16	6	38
A35	6289200N	681100E	3a	Ap	4	0	0
A36	6291100N	679200E	3a	Ap	1	0	0
A37	6274700N	666100E	3a	Mm	7	2	29
A38	6290800N	679500E	3a	Ap	9	1	11
A39	6290350N	679200E	3a	Ap	1	0	0
A40	6290350N	679000E	3a	Ap	23	6	26
A41	6290500N	677600E	3a	Ap	16	2	13
A42	6289800N	678400E	3a	Ap	11	0	0
A43	6289600N	678000E	3a	Ap	16	0	0
A44	6289400N	677800E	3a	Ap	7	0	0
A45	6289750N	678200E	3a	Ap	19	5	26

Spot	Spot locations North	East	Vegetation	Soil	Total no.of species	Exotic species	Percent exotic species
A46	6291500N	679500E	3a	Ap	25	4	16
A47	6294000N	684250E	3a	Gn	15	5	33
A48	6274200N	666200E	3a	Mm	17	7	41
A49	6274000N	666000E	3a	Mm	18	5	28
A50	6290000N	675400E	3a	Ap	17	1	6
A51	6289400N	677200E	3a	Ap	19	1	5
A52	6289250N	677500E	3a	Ap	17	4	24
A53	6291000N	675200E	3a	Ap	20	4	20
A54	6292400N	676500E	3a	Ap	8	0	0
A55	6292750N	677900E	3a	Ap	8	4	50
A56	6291600N	678200E	3a	Ap	15	0	0
A57	6291600N	678800E	3a	Ap	5	0	0
A58	6292500N	674750E	3a	Ap	17	5	29
A59	6301000N	696600E	C	Gn	23	8	35
A60	6306300N	695400E	OA/22	Gn	10	6	60
A61	6280900N	671100E	3b	Mm	9	0	0
A62	6280000N	671000E	3b	Mm	37	1	3
A63	6278900N	670800E	3a	Mm	13	2	15
A64	6276800N	670500E	3a	Ap/Mm	24	2	8
A65	6276400N	670400E	3a	Ap/Mm	23	4	17
A66	6274200N	670100E	3a	Ap	23	5	22
A67	6271250N	664100E	3a	Mm	2	0	0
A68	6282000N	671400E	3b	Ap/Mm	32	2	6
A69	6314000N	687000E	3a	Mm	1	0	0
A70	6281000N	659000E	3a	Mm	9	0	0
A71	6281700N	660500E	3a	Mm	0	0	0
A72	6290750N	674700E	3a	Ap	4	0	0
A73	6281700N	660100E	3a	Mm	4	0	0

Spot	Spot locations North	East	Vegetation	Soil	Total no.of species	Exotic species	Percent exotic species
A74	6281500N	659700E	3a	Mm	6	0	0
A75	6290700N	679800E	3a	Ap	32	6	19
A76	6290700N	682700E	3a	Lh	5	0	0
A77	6284100N	672500E	3b	Ap	4	0	0
A78	6279400N	656250E	3a	Mm	5	1	20
A79	6312350N	687100E	3a	Ov	11	1	9
A80	6311700N	689100E	3a/3b/3c	Gn	3	0	0
A81	6310500N	688100E	3a	Gn	21	2	10
A82	6282700N	656900E	3a	Mm	18	4	22
A83	6275100N	659400E	3a	Mm	20	0	0
A84	6277500N	661900E	3a	Mm	4	0	0
A85	6305700N	687250E	4/30	Gn	8	0	0
A86	6279600N	654000E	3a	Mm	7	3	43
A87	6278600N	655800E	3a	Mm	27	3	11
A88	6266100N	660600E	4	Mm	2	0	0
A89	6264500N	657100E	3a	Mm	1	0	0
A90	6264000N	658000E	3a	Mm	1	0	0
A91	6260900N	658400E	3a	Mm	1	0	0
A92	6257100N	660400E	3a	Mm	1	0	0
A93	6262300N	649200E	3a	Mm	1	0	0
A94	6260750N	670000E	3a	Mm	1	0	0
A95	non existent						
A96	6262700N	649200E	3a	Mm	1	0	0
A97	6266600N	647400E	3a	Mm	1	0	0
A98	6263500N	658500E	3a	Mm	1	0	0
A99	6270600N	661250E	3a	Mm	1	0	0
A100	6260800N	658000E	3a	Mm	1	0	0
A101	6262600N	649100E	3a	Mm	1	0	0

Spot	Spot locations North	East	Vegetation	Soil	Total no.of species	Exotic species	Percent exotic species
A102	6269600N	670400E	3a	Ap	3	1	33
A103	6269600N	671800E	3a	Ap	47	7	7
A104	6262800N	658200E	3a	Mm	1	0	0
A105	6269200N	672600E	3a	Mu	33	6	18
A106	6272800N	670600E	3a	Ap	1	0	0
A107	non existent						
A108	non existent						
A109	6267400N	649500E	3a	Mm	9	0	0
A110	6262900N	661600E	3a	Mm	21	5	24
A111	6261600N	662000E	3a	Mm	7	0	0
A112	6261200N	661000E	3a	Mm	11	2	18
A113	6259500N	658100E	3a	Mm	5	0	0
A114	6260100N	658100E	3a	Mm	15	1	7
A115	6260100N	658500E	3a	Mm	14	2	14
A116	6261700N	658650E	3a	Mm	11	0	0
A117	6262800N	658850E	3a	Mm	7	0	0
A118	6262600N	669600E	3a	Mm	10	1	10
A119	6263700N	669800E	3a	Mm	4	0	0
A120	6264400N	670000E	3a	Mm	10	0	0
A121	6265100N	670000E	3a	Mm	6	0	0
A122	6261500N	648900E	3b	Mm	9	0	0
A123	6264200N	649100E	3a	Mm	2	0	0
A124	6265600N	649300E	3a	Mm	5	1	20
A125	6266800N	651500E	3a	Mm	9	0	0
A126	6266500N	652500E	3a	Mm	3	0	0
A127	6266100N	652100E	3a	Mm	1	0	0
A128	6269500N	672400E	8/22	Mu	2	0	0
A129	6269200N	671800E	8/22	Mu	9	17	11
A130	6271400N	671300E	8/22	Mu	7	0	0

Transects 1–56: 1995

57–66, 97–108: Northern 1997
67–96: Central 1997
109–130: Southern 1997
Site key: A.l. = *Acacia ligulata*, A.o. = *Alectryon oleifolius* subsp. *canescens*, B.o. = *Beyeria bursariifolia*, Ca.p. = *Callitris preissii*, C.p. = *Casuarina pauper*, D.b. = *Dodonaea bursariifolia*, D.h. = *Duboisia hopwoodii*, D.v. = *Dodonaea viscosa*, G.p. = *Grevillea pterosperma*, L.c. = *Leptospermum coriaceum*, T.s. = *Triodia scariosa*. (X) = number of quadrats out of a total of 10, in which *Triodia scariosa* was found.

Transects

T	North	East	Vegetation	Soil	Site	Ordination group	Total no. of species	Exotic species	% exotic species
1	6296200N	664900E	3a	Ov	Mallee, no T.s.	1	57	9	16
2	6295000N	667400E	3a	Mm	Mallee, T.s. (6)	3	49	5	10
3	6294000N	669200E	3a	Mm	Open C.p., no T.s.	3	53	7	13
4	6292100N	678600E	3a	Ap	Mallee, Ca.p., T.s. (7)	1	50	6	12
5	6291700N	678600E	3a	Ap	Mallee, T.s. (10)	2	28	1	4
6	6291900N	678400E	3a	Ap	Mallee dune crest, T.s. (7)	1	46	4	9
7	6291400N	678000E	3a	Ap	Dense mallee, T.s. (10)	2	39	2	5
8	6292800N	677300E	3a	Ap	Mallee, Ca.p.,T.s (10)	2	28	0	0
9	6291600N	676400E	3a	Ap	Lake Shore, D.h., no T.s.	1	40	10	25
10	6290800N	674200E	3a	Mm	Mallee, T.s. (2)	3	57	5	9
11	6290700N	674800E	3a	Mm/Ap	Lake bed, no T.s.	3	46	10	22
12	6290300N	674700E	4	Mm/Ap	Mallee, T.s. (9)	1	40	1	3
13	6291300N	675600E	3a	Ap	Mallee, T.s. (8)	1	49	6	12
14	6291200N	675900E	3a	Ap	Mallee on dune crest, T.s. (10)	1	53	4	8
15	6290200N	676750E	4	Mm/Ap	Mallee on dune crest, T.s. (10)	2	35	1	3
16	6291600N	676750E	3a	Ap	Mallee, Ca.p., T.s. (9)	2	24	3	13

Transects

T	North	East	Vegetation	Soil	Site	Ordination group	Total no. of species	Exotic species	% exotic species
17	6291100N	677600E	3a	Ap	Mallee, T.s. (9)	2	28	1	4
18	6291250N	678200E	3a	Ap	Mallee, G.p., T.s. (10)	2	24	0	0
19	6290700N	679100E	3a	Ap	Lake edge mallee, D.h., T.s. (9)	2	31	3	10
20	6291000N	680000E	3a	Ap	Lake bed, no T.s.	3	33	9	27
21	6290750N	680000E	3a	Ap	Sparse mallee, T.s. (9)	1	57	10	18
22	6294500N	673800E	OA/4sc	Mm	Sandy low mallee, T.s. (10)	2	28	1	4
23	6294400N	675700E	3a	Mm	Mallee on red sand, no T.s.	1	52	4	8
24	6294000N	675600E	3a	Mm	Low mallee, T.s. (8)	2	29	1	3
25	6293800N	677000E	3a	Mm	Mallee on red sand, T.s. (10)	2	36	1	3
26	6293300N	679900E	3a	Ap	Mallee, T.s. (9)	2	31	2	6
27	6293300N	680700E	3a	Ap	Dune crest mallee, red sand, T.s. (10)	1	45	3	7
28	6293300N	681400E	3a	Mm	Dune crest mallee, red sand, T.s. (10)	1	45	4	9
29	6293200N	682900E	3a	Mm	Dune crest mallee, red sand, T.s. (8)	1	51	5	10
30	6292900N	683000E	3a	Mm	Dune crest mallee, red sand, T.s. (3)	1	49	7	14
31	6291200N	682800E	3a	Lh	Mature mallee, T.s. (9)	2	26	3	12
32	6289200N	680800E	3b	Ap	Mallee, red sand, T.s. (3)	1	52	11	21
33	6289100N	681500E	3b	Ap	Mallee, Ca.p., T.s. (5)	1	47	8	17
34	6292400N	677600E	3a	Ap	Mallee, Ca.p., T.s. (10)	2	21	3	14
35	6309200N	696700E	4/30	Gn	D.v., no T.s. (mapped as Hopwood community by Porteners et al. 1997)	3	45	9	20
36	6290400N	679300E	3a	Ap	Mallee, G.p., T.s. (10)	1	47	8	17
37	6290300N	678750E	3a	Ap	Mallee, lichens, T.s. (9)	2	29	1	3
38	6289900N	678100E	3b	Ap	Dune crest mallee, surface clay/loam, T.s. (8)	3	32	1	3

Transects T	North	East	Vegetation	Soil	Site	Ordination group	Total no. of species	Exotic species	% exotic species
39	6290200N	677800E	3b	Ap	Mallee on rocky outcrop, C.p., T.s. (2)	3	44	6	14
40	6290300N	678300E	3a	Ap	Depression, Ca.p., T.s. (9)	1	38	8	21
41	6291250N	679600E	3a	Ap	Mallee, T.s. (9)	2	24	6	25
42	6291400N	679800E	3a	Ap	Depression, D.h., T.s. (7)	1	28	6	21
43	6291750N	679300E	3a	Ap	Lake bed, no T.s.	3	36	7	19
44	6291900N	679100E	3a	Ap	Mallee, no T.s.	1	39	7	18
45	6297200N	679500E	3a	Mm	C.p. woodland, no T.s.	3	28	2	7
46	6289100N	676900E	3b	Ap	Mallee, open sand, T.s. (4)	1	36	3	8
47	6289000N	677500E	3b	Ap	Mallee on clay depression, C.p., no T.s.	3	46	2	4
48	6290100N	675250E	3b	Ap	Mallee, Ca.p., T.s. (4)	2	43	4	9
49	6291400N	674750E	3a	Mm	Mallee, T.s. (10)	1	36	3	8
50	6293200N	677600E	3a	Ap	D.v., no T.s.	3	41	7	17
51	6293300N	678000E	3a	Ap	Mallee, Ca.p., T.s. (2)	2	25	3	12
52	6283600N	671600E	3b	Ap	Dune crest mallee, T.s. (10)	2	28	2	7
53	6282600N	671400E	3b	Ap	Dune crest mallee, T.s. (7)	2	47	3	6
54	6281200N	671100E	3a	Mm/Ap	Mallee, T.s. (10)	2	37	4	11
55	6275600N	670400E	3a	Ap	Lake bed, A.o., T.s. (4)	3	34	6	18
56	6275000N	666400E	3a	Mm	Mallee, T.s. (10)	1	31	3	10
57	6314100N	687900E	3b	Mm	Lake bed, C.p., no T.s.	3	31	2	6
58	6312800N	688800E	3a	Mm	Dune crest, sandy, mallee, no T.s.	1	49	5	10
59	6312200N	688200E	3a	Mm	Mallee, T.s. (10)	2	28	2	7
60	6311800N	688000E	3a	Mm	Dune crest, sandy, L.c., T.s. (10)	1	19	1	5
61	6311900N	686800E	3a	Mm	Mallee, T.s. (10)	2	29	1	3

Transects

T	North	East	Vegetation	Soil	Site	Ordination group	Total no. of species	Exotic species	% exotic species
62	6312000N	685300E	3a	Mm	Mallee, T.s. (10)	2	13	0	0
63	6311200N	685100E	3a	Mm	Mallee, no T.s.	3	50	8	16
64	6310000N	688200E	3a	Mm	Dune crest, L.c., T.s. (3)	1	32	2	6
65	6309750N	688200E	3a	Mm	Lake bed, no T.s.	3	26	5	19
66	6308400N	687400E	3a	Mm	Mallee, T.s. (9)	1	52	6	12
67	6280600N	659700E	3a	Mm	Mallee, T.s. (10)	2	22	0	0
68	6280500N	660600E	3a	Mm	Mallee, L..c., T.s. (10)	2	23	1	4
69	6281400N	660600E	3a	Mm	Mallee, T.s. (10)	2	19	0	0
70	6282700N	660100E	3a	Mm	Mallee, T.s. (10)	2	20	1	5
71	6283400N	660000E	3a	Mm	Dune crest, A.l., T.s. (5)	2	33	4	12
72	6288500N	668400E	4	Mm	Lake bed, C.p., no T.s.	3	43	2	5
73	6288000N	668550E	3b	Mm	Lake bed, no T.s.	3	34	0	0
74	6287600N	668600E	3b	Mm	Mallee, T.s. (4)	1	55	6	11
75	6286400N	669200E	3b	Mm	Mallee, T.s. (10)	2	34	0	0
76	6284700N	668900E	3b	Mm	Mallee, T.s. (8)	1	43	1	2
77	6284500N	670600E	3b	Mm	Lake bed, C.p., no T.s.	3	29	0	0
78	6290700N	674800E	3a	Mm	Lake bed, no T.s.	3	40	5	13
79	6291250N	678200E	3a	Ap	Mallee on gravel slope, T.s. (10)	2	19	0	0
80	6287800N	673000E	4	Mm	C.p., no T.s.	3	30	0	0
81	6286700N	671800E	3b	Mm	D.v., no T.s.	3	33	3	9
82	6284750N	671500E	3b	Mm	Lake bed, A.o. with mallee, no T.s.	3	40	3	8
83	6283500N	670500E	3b	Ap	Mallee near dune crest, T.s. (9)	2	34	2	6
84	6280400N	671750E	3a	Mm	Mallee, T.s. (9)	2	29	0	0

Transects T	North	East	Vegetation	Soil	Site	Ordination group	Total no. of species	Exotic species	% exotic species
85	6280100N	671500E	3a	Mm	Dune crest, A.. l., T.s. (10)	2	26	1	4
86	6281700N	671000E	3b	Ap	Lake bed, C.p., A.o., no T.s.	3	57	5	9
87	6281400N	670000E	3a	Ap	Ridgetop with mallee, T.s. (10)	2	33	2	6
88	6280900N	667900E	3a	Mm	Sparse mallee, A.l., T.s. (5)	2	34	1	3
89	6281200N	665750E	3a	Mm	Lake bed, no T.s.	3	47	5	9
90	6279900N	664200E	3a	Mm	Sparse mallee, T.s. (4)	2	33	2	6
91	6277900N	661900E	3a	Mm	Lake bed, no T.s.	3	47	4	9
92	6276800N	658500E	3a	Mm	Lake bed, C.p., no T.s.	3	37	1	3
93	6277850N	657600E	3a	Mm	Lake bed, C.p., no T.s.	3	20	1	5
94	6278700N	656100E	3a	Mm	Open sand plain, T.s. (1)	1	38	5	13
95	6279700N	653000E	3a	Mm	Mallee with B.o., T.s. (5)	2	30	0	0
96	6278400N	656700E	3a	Mm	Mallee on gravel slope, T.s. (6)	2	25	0	0
97	6311000N	689900E	3a	Mm	Sand dune mallee, T.s. (4)	1	50	5	10
98	6310700N	689200E	3a	Mm	Low sand ridge, open mallee woodland, no T.s.	1	34	4	12
99	6310400N	688900E	3a	Mm	Ridgetop woodland, A.o., no T.s.	1	48	13	27
100	6309900N	687400E	3a	Mm	Lake bed, C.p., A.o., no T.s.	3	38	6	16
101	6308700N	686000E	3a	Mm	Mallee, T.s. (10)	2	29	3	10
102	6307400N	685900E	3a	Mm	Mallee, T.s. (8)	2	28	0	0
103	6306500N	685800E	3a	Mm	Mallee, T.s. (8)	2	23	1	4
104	6305800N	687100E	3a	Mm	Lake bed, C.p., A.o., no T.s.	3	54	6	11
105	6306700N	687200E	3a	Mm	Mallee, T.s. (10)	2	25	2	8
106	6307700N	686900E	3a	Mm	Mallee, T.s. (8)	2	30	1	3
107	6308200N	687200E	3a	Mm	Dune ridge, A.o., no T.s.	1	46	10	22

Transects

T	North	East	Vegetation	Soil	Site	Ordination group	Total no. of species	Exotic species	% exotic species
108	6308900N	687800E	3a	Mm	Mallee, T.s. (10)	2	29	3	10
109	6267400N	649500E	3a	Mm	D.v., no T.s.	3	33	5	15
110	6262900N	661600E	3a	Mm	Mallee on dune crest, T.s. (8)	2	46	6	13
111	6261600N	662000E	3a	Mm	Mallee on dune crest, T.s. (2)	2	43	2	5
112	6261200N	661000E	3a	Mm	Swale of parabolic dune, no T.s.	3	23	3	13
113	6259500N	658100E	3a	Mm	Mallee on dune crest, T.s. (9)	2	44	1	2
114	6260100N	658100E	3a	Mm	Mallee on red swale, D.b., T.s. (2)	2	30	0	0
115	6260100N	658500E	3a	Mm	Sand plain mallee, T.s. (10)	2	40	2	5
116	6261700N	658650E	3a	Mm	Sand plain mallee, T.s. (10)	2	30	0	0
117	6262800N	658850E	3a	Mm	Sand plain mallee, T.s. (8)	2	25	0	0
118	6262600N	669600E	3a	Mm	Sand plain mallee, T.s. (7)	2	40	0	0
119	6263700N	669800E	3a	Mm	Mallee on red swale, T.s. (10)	2	26	0	0
120	6264400N	670000E	3a	Mm	Dune crest mallee, T.s. (10)	2	27	0	0
121	6265100N	670000E	3a	Mm	Sand plain mallee, T.s. (9)	2	18	1	6
122	6261500N	648900E	3b	Mm	Red swale, T.s. (3)	2	32	0	0
123	6264200N	649100E	3a	Mm	Sand plain mallee, T.s. (10)	2	26	0	0
124	6265600N	649300E	3a	Mm	Dune crest mallee, T.s. (8)	2	31	0	0
125	6266800N	651500E	3a	Mm	Mallee on red swale, no T.s.	3	45	5	11
126	6266500N	652500E	3a	Mm	Dune crest mallee, T.s. (10)	2	13	0	0
127	6266100N	652100E	3a	Mm	Sand plain mallee, T.s. (9)	2	25	0	0
128	6269500N	672400E	8/22	Mu	Lake bed, no T.s.	3	58	11	19
129	6269200N	671800E	8/22	Mu	Lake bed, no T.s.	3	32	6	19
130	6271400N	671300E	8/22	Mu	Lake bed, no T.s.	3	39	9	23

Appendix 2. Ephemeral Species

Key : * : exotic species
95: 1995 survey
97e: entire 1997 survey
N: northern area, 1997
C: central area, 1997
S: southern area, 1997

Species	95	97e	N	C	S
Dicotyledons					
Aizoaceae					
Tetragonia moorei sp. nov.	x	x	x	x	x
Apiaceae					
Daucus glochidiatus	x	x	x	x	x
Trachymene cyanopetala	x	x		x	x
Trachymene sp. (unidentified)		x		x	
Asteraceae					
Actinobole uliginosum	x	x	x	x	x
Angianthus brachypappus		x			x
Angianthus tomentosus		x			x
Brachycome leptocarpa	x				
Brachycome lineariloba	x	x	x	x	x
Bracteantha bracteata	x				
Calotis cymbacantha	x				
Calotis hispidula	x	x	x	x	x
**Carthamus lanatus*	x				
**Centaurea melitensis*	x	x	x		
Centipeda thespidioides	x				
Ceratogyne obionoides		x		x	x
Chthonocephalus pseudevax		x	x	x	x
Epaltes australis	x				
Gnaphalium sphaericum	x	x		x	
Gnephosis eriocarpa	x				
Gnephosis tenuissima	x	x	x	x	x
Hyalosperma semisterile		x			x
**Hypochoeris glabra*	x	x	x	x	x
Isoetopsis graminifolia	x	x	x	x	x
Lemooria burkittii	x	x	x	x	x
Millotia macrocarpa	x	x	x	x	x
Millotia perpusilla		x		x	x
Millotia tenuifolia var. *tenuifolia*		x			x
Myriocephalus pluriflorus		x		x	
Myriocephalus stuartii	x	x	x	x	x
Podolepis capillaris	x	x	x	x	x
Podolepis sp. (unidentified)		x		x	
Podotheca angustifolia	x	x		x	x
Pogonolepis muelleriana	x	x		x	x
Pseudognaphalium luteoalbum	x				
Rhodanthe corymbiflora		x			x
Rhodanthe floribunda	x	x	x		
Rhodanthe microglossa	x				
Rhodanthe moschata	x	x	x	x	x
Rhodanthe pygmaea		x	x	x	x
Rhodanthe sp.		x			x
Rhodanthe stuartiana		x	x	x	x
Rhodanthe uniflora	x	x			x
Senecio glossanthus	x	x	x	x	x
Senecio gregorii	x				
**Sonchus asper*		x	x		
**Sonchus oleraceus*	x	x	x		x
Stuartina hamata		x		x	

Species	95	97e	N	C	S
Asteraceae cont.					
Stuartina muelleri		x			x
Triptilodiscus pygmaeus	x	x		x	x
Vittadinia cervicularis subsp. *cervicularis*		x	x		x
Vittadinia cuneata var. *morrisii*	x	x	x	x	
Vittadinia dissecta var. *hirta*	x	x	x	x	x
Vittadinia eremaea	x	x	x	x	x
Vittadinia pterochaeta	x	x		x	
Vittadinia sp.	x	x	x	x	x
Vittadinia sulcata	x	x	x	x	
Waitzia acuminata	x	x	x	x	x
Boraginaceae					
**Echium plantagineum*	x				
Omphalolappula concava	x	x	x	x	x
Plagiobothrys plurisepaleus		x	x	x	x
Brassicaceae					
**Alyssum linifolium*	x	x	x	x	x
Blennodia canescens	x	x	x	x	
**Brassica tournefortii*	x	x	x	x	x
**Carrichtera annua*		x	x		
Geococcus pusillus		x			x
Harmsiodoxa brevipes var. *brevipes*	x	x	x	x	x
Lepidium fasciculatum	x				
Lepidium monoplocoides		x		x	
Lepidium papillosum	x	x	x	x	x
Lepidium phlebopetalum	x	x	x	x	x
**Lepidium* sp.		x	x	x	x
Menkea australis		x	x	x	x
Sisymbrium erysimoides		x		x	x
Stenopetalum lineare	x	x	x	x	x
Stenopetalum sphaerocarpum		x		x	x
Campanulaceae					
Wahlenbergia gracilenta	x	x	x	x	x
Wahlenbergia tumidifructa	x	x	x	x	
Caryophyllaceae					
Gypsophila australis		x	x		
**Herniaria hirsuta*	x	x	x	x	
**Sagina apetala*		x		x	
Scleranthus minusculus	x	x	x	x	x
**Silene apetala*	x	x	x	x	x
**Silene nocturna*		x			x
Chenopodiaceae					
Chenopodium cristatum	x	x		x	x
Chenopodium desertorum subsp. *desertorum*			x	x	x
Chenopodium desertorum subsp. indet.	x				
Chenopodium desertorum subsp. *rectum*	x		x	x	x
Chenopodium melanocarpum	x	x	x	x	x
Crassulaceae					
Crassula colorata var. *acuminata*	x	x	x	x	x
Euphorbiaceae					
Poranthera microphylla	x	x		x	
Fabaceae Faboideae					
**Medicago laciniata*		x	x		
**Medicago minima*	x	x	x	x	x
Geraniaceae					
**Erodium cicutarium*	x	x	x	x	x
Erodium crinitum	x	x	x	x	x
Erodium cygnorum subsp. *glandulosum*	x	x	x	x	
Erodium sp.		x	x	x	

Species	95	97e	N	C	S
Goodeniaceae					
Goodenia havilandii	x	x	x	x	x
Goodenia pusilliflora	x	x	x	x	x
Malvaceae					
**Malva parviflora*	x				
Plantaginaceae					
Plantago cunninghamii	x				
Plantago drummondii	x	x		x	x
Plantago sp.		x	x		x
Plantago turrifera	x	x	x	x	x
Portulacaceae					
Calandrinia eremaea	x	x	x	x	x
Calandrinia granulifera		x		x	x
Ranunculaceae					
Myosurus minimus var. *australis*	x				
Ranunculus pentandrus var. *platycarpus*		x			x
**Ranunculus trilobus*	x				
Rubiaceae					
Synaptantha tillaeacea		x		x	
Solanaceae					
Nicotiana occidentalis subsp. *obliqua*	x		x	x	x
Thymelaeaceae					
Pimelea trichostachya	x	x	x	x	x
Urticaceae					
Parietaria debilis		x	x	x	x
Zygophyllaceae					
Zygophyllum ammophilum	x	x	x	x	x
Zygophyllum apiculatum	x	x	x	x	x
Zygophyllum aurantiacum	x				
Zygophyllum iodocarpum	x	x	x	x	
Zygophyllum ovatum	x	x	x	x	
Zygophyllum simile	x	x	x	x	x
Monocotyledons					
Asphodelaceae					
Bulbine semibarbata	x	x	x	x	x
Juncaginaceae					
Triglochin calcitrapum		x	x	x	x
Poaceae					
Agrostis avenacea	x				
**Aira caryophyllea*	x	x	x	x	
Bromus arenarius	x	x	x	x	x
**Bromus rubens*	x	x	x	x	x
**Bromus* sp.	x				
**Hordeum leporinum*	x	x	x		
**Hordeum marinum*		x			x
Pentaschistis airoides		x	x	x	x
Poa fax	x				
**Rostraria pumila*	x	x	x	x	x
**Schismus barbatus*	x	x	x	x	x
**Vulpia bromoides*	x	x			x
**Vulpia muralis*	x	x		x	
**Vulpia myuros*	x	x	x	x	x
**Vulpia* sp.		x		x	x

Vegetation and flora of Booti Booti National Park and Yahoo Nature Reserve, lower North Coast of New South Wales.

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Griffith, S.J.[1], Wilson, R.[2] and Maryott-Brown, K.[3] ([1]Division of Botany, School of Rural Science and Natural Resources, University of New England, Armidale NSW 2351; [2]16 Bourne Gardens, Bourne Street, Cook ACT 2614; [3]Paynes Lane, Upper Lansdowne NSW 2430) 2000. Vegetation and flora of Booti Booti National Park and Yahoo Nature Reserve, lower North Coast of New South Wales. Cunninghamia *6(3): 645–715.* The vegetation of Booti Booti National Park and Yahoo Nature Reserve on the lower North Coast of New South Wales has been classified and mapped from aerial photography at a scale of 1: 25 000. The plant communities so identified are described in terms of their composition and distribution within Booti Booti NP and Yahoo NR. The plant communities are also discussed in terms of their distribution elsewhere in south-eastern Australia, with particular emphasis given to the NSW North Coast where compatible vegetation mapping has been undertaken in many additional areas. Floristic relationships are also examined by numerical analysis of full-floristics and foliage cover data for 48 sites. A comprehensive list of vascular plant taxa is presented, and significant taxa are discussed. Management issues relating to the vegetation of the reserves are outlined.

Introduction

The study area

Booti Booti National Park (1586 ha) and Yahoo Nature Reserve (48 ha) are situated on the lower North Coast of New South Wales (32°15'S 152°32'E), immediately south of Forster in the Great Lakes local government area (Fig. 1). The reserves fall within the NSW North Coast biogeographic region of Thackway and Cresswell (1995), and the North Coast botanical subdivision of Anderson (1961).

The larger part of Booti Booti NP consists of Quaternary barrier deposits between the Pacific Ocean and Wallis Lake connecting three headland hill complexes. Several small islands in Wallis Lake are also included in Booti Booti NP — Booti Island, Shepherd Island, Coomba Island, Earps Island, Snake Island, Little Snake Island, Black Rocks and Pelican Island. Yahoo NR is a larger island, also in Wallis Lake.

The present paper is based on a vegetation survey which was undertaken by the authors for the NSW National Parks and Wildlife Service, Hunter District (Griffith et al. 1999).

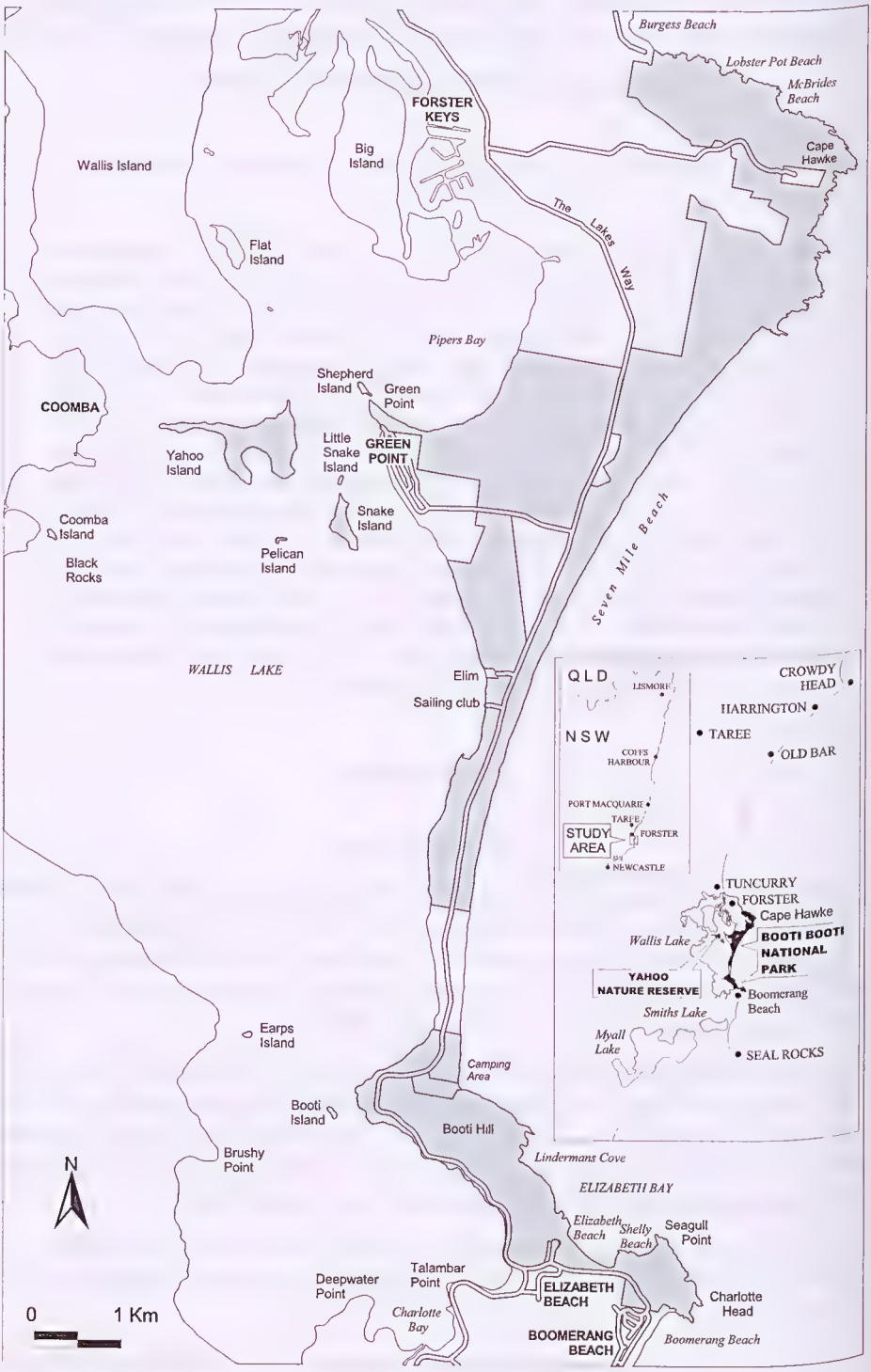


Fig. 1. The location of Booti Booti National Park and Yahoo Nature Reserve (shaded) on the lower North Coast of New South Wales.

Climate

The lower North Coast of NSW experiences a humid subtropical climate (Koeppen typology) which is characterised by mild winters, long hot summers, and precipitation in all seasons. The dominant winter air mass is the polar maritime, and this influences weather patterns for a minimum of 3–6 months (after Oliver 1973, in Linacre and Hobbs 1977). At this time of the year strong, cold winds originate in the south or west. Tropical maritime air dominates in summer for a minimum of three months, and during this time winds often originate in the north or north-east.

The mean annual rainfall for Taree (36 km NNW of Booti Booti NP) is 1178 mm, and an average of 35% of this total falls during the three wettest months of January, February and March. The three driest months of July, August and September receive an average of 17% of the mean annual total. However, annual and seasonal rainfall patterns can vary considerably from year to year, and so result in periods of drought or flood. To illustrate this point, 110 years of record for Harrington (40 km N of Booti Booti NP) yield a variability index for total annual rainfall of 70% (variability index = (90% percentile - 10% percentile)/50% percentile). Similarly, the variability index for monthly rainfall in March (the wettest month on average) is 175%. For monthly rainfall in September (the driest month on average), the variability index is 294% (Bureau of Meteorology 1988; Bureau of Meteorology pers. comm. 1998).

Mean daily maximum temperatures for Taree vary from 28.3 to 28.9°C in the summer months, and from 18.6 to 20.1°C in the winter months. Likewise, mean daily minimum temperatures vary from 16.4 to 18.1°C in summer, and from 5.3 to 7.2°C in winter (Bureau of Meteorology 1988). Frosts are rare in the vicinity of Booti Booti NP and Yahoo NR.

Landforms, geology and soils

Booti Booti NP contains three large hill complexes (landform terms generally follow Speight 1984), and these are dominated by Cape Hawke, Booti Hill and Charlotte Head respectively (Fig. 1). The Cape Hawke complex and the Charlotte Head complex are both composed of sandstone and conglomerate strata of the Conger Formation from the Carboniferous Period. The Booti Hill complex is part of the Wooton Beds, which are also Carboniferous and comprise sandstone, siltstone, claystone, shale, limestone and lavas (NSW Department of Mines 1966). All three hill complexes are interconnected with Quaternary deposits of marine-aeolian and estuarine origin. The Cape Hawke and Charlotte Head complexes were at one time offshore islands, whereas the Booti Hill complex has always been a headland promontory of the mainland (Melville 1984).

The largest hill complex is dominated by Cape Hawke (224 m high). Apart from small beaches such as McBrides and Lobster Pot, the northern and eastern margins of the Cape Hawke complex end in cliffs and rocky outcrops along the ocean. At the south-western extremities, the complex is mantled to an elevation of approximately 50 m with quartzose sands of considerable age (> 140 000 years BP), although these sands have since eroded along gullies (de Castro Lopo 1981, Roy 1982).

During the late Pleistocene the Cape Hawke hill complex was an offshore island some 10 km out to sea and 12 km^2 in area. Refracted waves subsequently formed a tombolo-like lagoon barrier by joining the Cape Hawke complex (and the smaller island of Green Point) to the protruding headland of Booti Hill (Melville 1984). The former island of Charlotte Head also joined with the mainland in the late Pleistocene as a result of deposition. The main phase of Pleistocene barrier sedimentation commenced approximately 140 000 years BP, and this time corresponds with the Last Interglacial Marine Transgression when sea levels were higher (Roy 1982).

The present-day lagoon barrier which extends south from the Cape Hawke hill complex to the Booti Hill complex is approximately 10 km in length, and varies in width from 400 m to 3.25 km. This lagoon barrier separates Wallis Lake from the Pacific Ocean. The seaward sequence of the lagoon barrier consists of Holocene marine-aeolian deposits which overly or interface with low-lying and partly eroded Pleistocene sands, some of which are humate-cemented. In Wallis Lake, Pleistocene sands extend to a depth of 25 m below the present sea level. The western (lake) side of the lagoon barrier consists of sediments of estuarine origin. These sediments are sandy backbarrier deposits of Pleistocene age, Holocene backbarrier washover and tidal delta sands, and Holocene basin mud and intertidal deposits. Estuarine clays and clayey sands underlie all of the abovementioned sediments, and these estuarine deposits in turn rest on bedrock (Melville 1984, Roy 1982). Much of the present lagoon barrier is less than 10 m in elevation, although sand dunes reach a height of 20–30 m at a few locations. The landform pattern of the lagoon barrier is rolling to level.

The Booti Hill hill complex extends about 3 km in a north-west to south-east direction, and varies in width from 600 m to 1 km. The highest point in this complex is Booti Hill itself (169 m). Hillslopes on the south-western side of the complex form the shore of Wallis Lake, while the north-eastern and eastern slopes often terminate in sea cliffs. Elizabeth Beach occupies a protected situation between the Booti Hill complex and the Charlotte Head complex. Elizabeth Beach consists of Holocene marine-aeolian sands which onlap sandy backbarrier deposits of Pleistocene age and estuarine origin (Roy 1982).

Of the three hill complexes in Booti Booti NP, the one dominated by Charlotte Head is the smallest and lowest (96 m). The Charlotte Head complex terminates in extensive sea cliffs to the east and north-east, and the southern part of the complex is mantled with aeolian sand. To the north-west the complex has an open depression which drains towards Shelly Beach.

Some of the islands in Wallis Lake are composed entirely or partly of bedrock, whereas other islands consist of Quaternary sediments only. Shepherd and Yahoo Islands contain a bedrock knoll (identified as toscanite for Yahoo Island in Floyd 1990) against which estuarine sediments have accumulated. On the other hand, Black Rocks, Booti Island, Earps Island and Coomba Island are entirely bedrock. Snake and Little Snake Islands consist of well vegetated tidal and supratidal sediments, whereas Pelican Island is a sandy tidal flat which is predominantly unvegetated.

The Soil Conservation Service of NSW (1985) has identified several soil groups for the bedrock hill complexes in Booti Booti NP. These groups are red and yellow podzolics, yellow earths and structured clays. Other soils which are known or likely to be present include gleyed podzolics on intermittently waterlogged lower slopes, lithosols on steep slopes and shallow hillcrests, and black headland soils (after Parbery 1947) and soloths on very exposed seaward aspects. The soils associated with older sand masses of the lagoon barrier form a catenary sequence from sand podzols on well-drained sites to humus podzols, peaty podzols and then acid peats in swamps. The younger sands associated with foredunes generally display little profile development other than a surface accumulation of organic matter. Along the margins of Wallis Lake the youngest estuarine deposits often display sediment interbedding, but no true profile development. Older estuarine deposits on the other hand display rudimentary pedological development in the form of a surface accumulation of organic matter. These minimally developed, saline soils are solonchaks.

Landuse and fire history

Approximately half (800 ha) of the present national park was originally designated as Booti Booti State Recreation Area in 1977, and this was administered by the NSW Department of Lands and an SRA Trust. Booti Booti SRA was managed for recreational activities such as fishing, swimming and camping, but with regard for intrinsic conservation values. In 1992 the former state recreation area was dedicated as Booti Booti NP under the administration of the NSW National Parks and Wildlife Service. Additions both before and after dedication as a national park have increased the total area to 1586 ha. Booti Booti NP is still managed for both passive recreation and nature conservation. Yahoo Island (48 ha) was dedicated as a nature reserve in 1983, and visitation has not been actively encouraged.

The entire length of Seven Mile Beach in Booti Booti NP was mined for heavy minerals during the period from 1969 to 1975, and mining also occurred at Elizabeth Beach from 1969 to 1970. The mine paths varied in width from approximately 50–350 m. **Casuarina equisetifolia* subsp. *incana* was established on the mined areas beyond what is considered to be its natural southern distribution limit in the vicinity of Laurieton, approximately 70 km to the north (Harden 1990).

Former clearings are evident on the Cape Hawke hill complex, some of which are attributable to abandoned banana plantations dating from about the time of World War II. A wildfire apparently burnt through rainforest on Cape Hawke approximately 60 years ago (D. Turner NPWS, pers. comm. 1999), and fire scars are still evident on many trees.

The fire history of Booti Booti NP and Yahoo NR is reasonably typical of coastal vegetation on the NSW North Coast in that frequent unprescribed fires result from non-natural or unknown sources. Fire records for the two reserves date from 1984, and since this time most of the vegetation in the reserves has been burnt on at least one occasion. The fire records further indicate that a wide variety of vegetation types have been burnt in the last 15 years, including stands of *Livistona australis* rainforest.

* Exotic or non-indigenous taxa are prefixed with an asterisk.

Fortunately, the extensive rainforests of the Cape Hawke hill complex have remained largely unburnt since 1984. A severe crown fire burnt most of the sand mass vegetation of Booti Booti NP in late January 1997. Yahoo NR last burnt in November 1994, and this fire affected most vegetation types other than dry rainforest on a boulder-strewn knoll.

Previous botanical surveys

Dodkin (1978) and Floyd (1990, undated) investigated the distribution and composition of rainforests in Booti Booti NP and Yahoo NR, while Clough (1979) undertook a more detailed comparative study with rainforests elsewhere on the lower North Coast. Species checklists are available from these earlier works.

The former Booti Booti SRA Trust and the NSW Department of Lands commissioned a more inclusive vegetation study by de Castro Lopo (1980). In this work Booti Booti SRA was divided into six divisions analogous to land systems (e.g. Sand Barriers Division), and 24 subdivisions (e.g. Stabilised Dune Subdivision). A detailed vegetation description and checklist was produced for each subdivision, as well as recommendations for management. In a subsequent publication, de Castro Lopo (1981) presented exploratory analyses of the species checklists compiled for each subdivision, although these analyses were limited by the internal heterogeneity of many of the map units for which the checklists and associated abundance data were collected.

The species checklists produced by Clough (1979), de Castro Lopo (1980), Dodkin (1978) and Floyd (1990, undated) have been incorporated into the present study. Other studies which deal with aspects of the vegetation of the reserves, or the vegetation of other parts of the Wallis Lake area, include the work of Adam et al. (1988, 1989), Brockhoff (1988), Browne and Scott (1985), and Griffith (1987).

Methods

Survey methods

Introduction

The present study is the most recent in a series of 1: 25 000 vegetation maps produced for coastal reserves of northern NSW. This work has been undertaken over a number of years by two of the present authors (S.J. Griffith and R. Wilson) for the NSW National Parks and Wildlife Service. Vegetation maps have been produced for all large coastal reserves of NSW to the north of Booti Booti NP (Broadwater NP, Bundjalung NP, Yuraygir NP, Hat Head NP, Limeburners Creek NR, Lake Innes NR, Crowdy Bay NP), and a number of smaller reserves (Ballina NR, Richmond River NR, Iluka NR, Moonee Beach NR, Arakoon SRA, Kattang NR). Several significant areas of coastal vegetation on freehold or crown land have also been mapped, for example the Newrybar sand plain at Lennox Head, lands at Evans Head north and south of the Evans River, lands to the north of Yuraygir NP in the vicinity of Wooloweyah Lagoon, and Frogalla swamp north of Forster (Fig. 2).

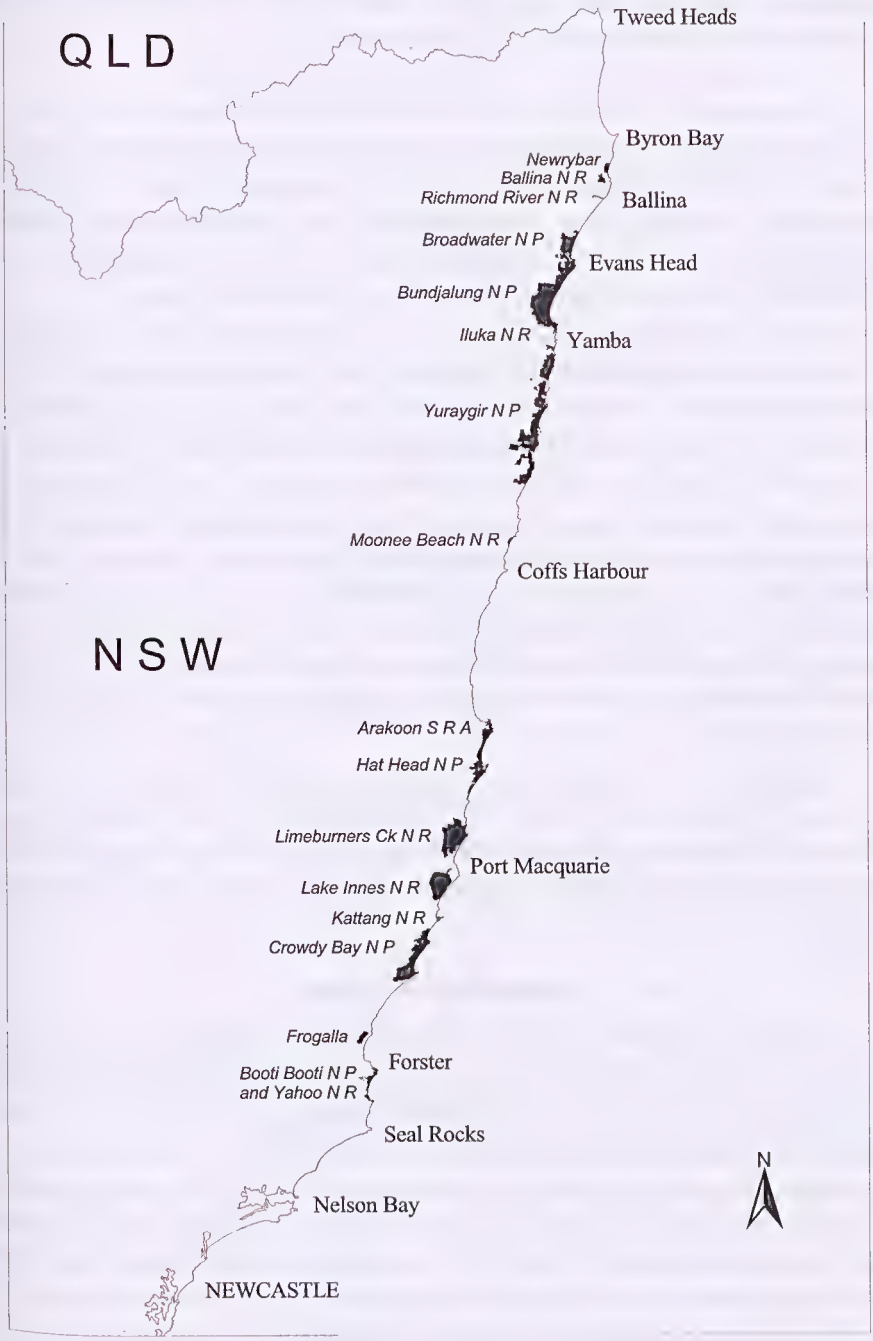


Fig. 2. National parks, nature reserves and other lands on the North Coast of New South Wales for which compatible vegetation mapping is available. These areas of coastal vegetation have been mapped to a scale of 1: 25 000 using the classification and coding system employed in the present study for Booti Booti NP and Yahoo NR.

All of the aforementioned mapping (around 84 000 ha) has been digitised using a minimum polygon size of approximately one hectare, and it is stored in a regional geographical information system (GIS) at the Northern Zone office of the NSW National Parks and Wildlife Service (Coffs Harbour).

Air photo interpretation and mapping

The vegetation of Booti Booti NP and Yahoo NR was mapped by means of air photo interpretation (API). Stereo-paired colour photography flown by the NSW Department of Land and Water Conservation was used, generally at a scale of 1: 25 000 (Bulahdelah series 1991, Runs 6, 7, 8, 9), although an incomplete coverage of 1: 10 000 photography was also used to confirm some vegetation boundaries.

Preliminary stratification of the vegetation into photo types was undertaken by reference to such diagnostic features as colour, texture, crown architecture, aspect and topographic position. A process of preliminary stratification, selective field sampling, and specification and interpretation adjustment was continued until a satisfactory level of confidence in photo type recognition was reached.

Selective field sampling (ground truthing) was undertaken by two people over a period of six days, and during this process observations were made of the structure and composition of each photo type. A species checklist was also compiled for each vegetation type during this fieldwork, although not for rainforests other than that dominated by *Choricarpia leptopetala*. Extensive checklists have already been produced for most rainforest types of the reserves by others (Clough 1979, Dodkin 1978, Floyd 1990, undated).

The boundaries of the photo types, which are generally analogous to plant associations (sensu Beadle 1981), were transcribed to CMA (Central Mapping Authority) 1: 25 000 topographic map bases, digitised, and then converted to ArcView 3.1 GIS (Environmental Systems Research Institute Inc.) format for final vegetation map production.

Vegetation classification

The structural classification used for mapping and community description follows Walker and Hopkins (1984), and the general range in height and crown cover for each community is expressed using two or more classes (e.g. mid-high to tall, open to closed forest; simple, tall to very tall closed fan palm forest).

Subformation names for vegetation types other than rainforest are adapted from the classification proposed by Beadle and Costin (1952), e.g. 'wet sclerophyll forest'. The subformation categories of Floyd (1990) are used for rainforests, although the distinction between littoral rainforest and subtropical rainforest has been maintained.

The communities are named after dominant indicator species of the tallest (dominant) stratum, and most could be considered associations using the definition of Beadle (1981): 'a community in which the dominant stratum exhibits uniform floristic composition, the community usually exhibiting uniform structure (also)'. In applying Beadle's definition, it is assumed that a particular stand is structurally uniform if it

spans two or less height classes (after Walker & Hopkins 1984), and two or less crown cover classes. In this way, for example, *Melaleuca quinquenervia* tall open woodland/woodland could be considered a separate association to *M. quinquenervia* tall open/closed forest. As observed in the field, subsidiary (10–30% of total crown cover) or minor (< 10% of total crown cover) associates of the tallest stratum are given in each plant community description. Emergents above the tallest stratum are also noted where present (generally < 5% of total crown cover for the tallest stratum). For strata beneath the tallest stratum, short lists of common species are provided.

Five-digit numeric codes are used for mapping purposes to identify individual plant communities, and also other map units such as cleared land. The decision to use numeric codes in preference to, say, alpha-numeric codes was originally made in the early 1980s to facilitate the compilation of data for fire behaviour modelling using PREPLAN software. At that time numeric codes were generally easier to manipulate and compute.

The first four digits of each code identify the formation, subformation and community. As an illustration, map codes 0000–4999 are reserved for formations in which the tallest stratum is dominated by trees, i.e. forest and woodland. Within the forest and woodland formations, map codes 3500–3999 are used for communities in the dry sclerophyll forest and woodland subformations. Dry sclerophyll forest and woodland in which *Eucalyptus pilularis* is the dominant indicator species has been assigned the map code 3504. A fifth digit is used on vegetation maps to signify the crown cover range of the tallest stratum in each polygon: 1 = mid-dense to dense (e.g. 3504<u>1</u> for *E. pilularis* open to closed forest); 2 = very sparse to sparse (e.g. 3504<u>2</u> for *E. pilularis* open woodland to woodland); 0 = crown cover variable, or else not determined. The '0' code is only used for 'complex' map units and 'miscellaneous' map units.

In some instances it was not possible to map communities discretely at a scale of 1: 25 000. This situation arose where communities were too fragmented and intermixed (e.g. along foredunes and sea cliffs), or else formed seemingly broad ecotones or 'mixed stands' (after Beadle 1981). In many situations where communities closely intermix, micro-relief varies over small distances. For simplicity of mapping, commonly encountered mixed stands which are perceived to comprise two communities have been assigned a distinct map code (e.g. 40991 for mixed swamp sclerophyll forest stands of *Melaleuca quinquenervia* and *Casuarina glauca*). Less common mixed stands are simply mapped using a dual code (e.g. 64021-65031). Fragmented and intermixed vegetation which comprises more than two communities is often found on foredunes, in saltmarshes, and along seacliffs. In such situations appropriately annotated 'complex' map units are employed. These are Foredune Complex (code 90100), Saltmarsh Complex (code 90200) and Headland Complex (code 90300) respectively. 'Miscellaneous' map units are further used to identify artificial, disturbed or predominantly unvegetated areas, for example clearings (code 92030), urban development (code 92090) and open water (code 91040). Occasionally a stand of vegetation grades from one structural formation into another over too small an area to be further subdivided at the mapping scale employed (e.g. where a forest stand grades into tree mallee or shrubland on its more exposed margins). In such cases the stand was mapped according to the predominant growth form.

The vegetation coding system has been consistently applied to vegetation mapping projects in coastal reserves and other lands of northern NSW (Fig. 2), and to date some 180 plant communities have been delineated and mapped. This vegetation classification and mapping system has formed the basis of fire management in many coastal reserves on the NSW North Coast (e.g. NSW National Parks and Wildlife Service 1997, 1998a,b). Sun et al. (1997) provide a generalised comparison of the vegetation classification and mapping system (as 'NSW NPWS Coastal Vegetation Mapping') with systems in use for other parts of NSW and Australia.

Plot-based sampling

Site stratification

A plot-based survey was undertaken in addition to the vegetation mapping, plant community description and species checklist compilation. The stratification of sites for plot-based sampling was initially attempted using environmental variables (geology, slope, aspect, elevation) and a GIS, rather than air photo patterns. Such a procedure has been employed in several other surveys for the NSW National Parks and Wildlife Service (e.g. Bell 1997, Sheringham & Sanders 1993), particularly in vegetation on rugged sandstone landforms in the Sydney region where changes in aspect and elevation are generally pronounced.

Unfortunately, subsequent attempts to assign sample sites using derived environmental category combinations (e.g. high quartz sedimentary bedrock, 0–2° slope, 0–89° aspect and 0–99 m elevation) proved unsatisfactory, primarily due to resolution limitations for the available GIS environmental layers. As an illustration, the GIS geology layer grouped all Pleistocene and Holocene deposits as 'Quaternary sand and alluvium' regardless of origin, degree of weathering, and soil formation environment. Coastal vegetation patterns, particulary on sand plains and around estuaries, are quite complex. In such areas vegetation patterns may change dramatically with only slight changes in elevation (< 0.5 m), and also with variations in groundwater hydrology which are often more closely linked to soil profile characteristics (e.g. depth and degree of induration of the B horizon) than to elevation above sea level.

In view of the perceived complexity of coastal vegetation, and the relative coarseness of the environmental layers which were available at the time of the survey, all attempts to stratify the vegetation using environmental variables were abandoned in favour of sampling a range of photo patterns. Sample sites were assigned by photo pattern following the preparation of a draft vegetation map (Fig. 3).

Data collection

Floristic data were collected for 49 sites in Booti Booti NP and Yahoo NR using quadrats of fixed size (400 m^2 wherever possible, but occasionally 200 m^2 or 100 m^2 in restricted vegetation types). The sampling was undertaken during the periods February to April 1998 and September 1998, and each site was permanently marked with a numbered metal picket. All vascular species present were recorded and assigned to one of six foliage cover (sensu Walker & Hopkins 1984) classes: 1 (< 5%

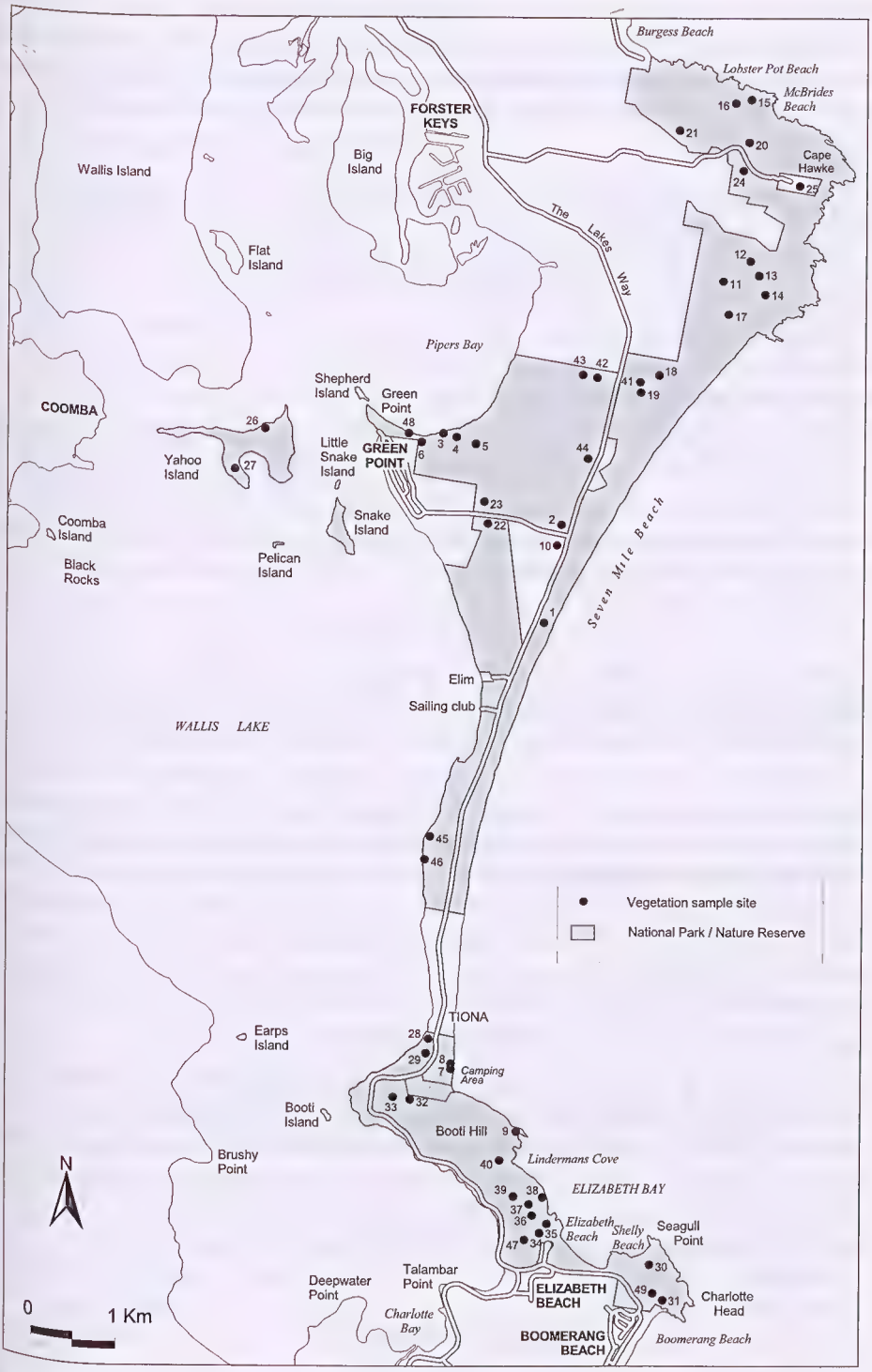


Fig. 3. Location of sites in Booti Booti NP and Yahoo NR at which plot-based sampling was undertaken. Sample sites were stratified on the basis of photo pattern after the preparation of a preliminary vegetation map.

cover and species uncommon); 2 (< 5% and common); 3 (6–20%); 4 (21–50%); 5 (51–75%); and 6 (76–100%). The nomenclature for plant taxa is consistent with current usage at the Royal Botanic Gardens Sydney, and most authorities are provided in Harden (1990–93). Exotic or non-indigenous taxa are prefixed with an asterisk.

The following attributes were also measured or estimated at each site:

- vegetation structure, including the height and foliage cover of each stratum;
- location, aspect, elevation and slope;
- angle to the horizon for the eight principal compass points;
- geology and general soil characteristics;
- topographic position;
- time since the last fire event; and
- forms of disturbance other than fire.

Data are available for all plant communities recognised during the vegetation mapping process, although budgetary constraints restricted the sampling intensity to a single quadrat in all but two communities (two quadrats were placed in each of the latter). The data for each site were recorded on a standard NPWS proforma, and archived with the NPWS, Hunter District.

Numerical analysis

Plant communities perceived from air photo interpretation are primarily distinquished on the basis of structure and, where resolution is adequate, floristic composition of the dominant stratum (and occasionally a second stratum). Plant communities so derived display a degree of floristic homogeneity for the tallest stratum, but this may not be the case for understorey strata. Conversely, it may be possible to distinguish different structural formations on aerial photographs (*e.g.* shrubland versus heathland), even though there is little obvious difference in floristic composition. All air photo interpretation is also scale dependent, and it is sometimes possible to further subdivide map units with the aid of larger scale photography. The degree of congruence between plant communities derived from air photo interpretation and phytosociological units derived solely from floristics can be examined by the numerical classification of site data.

Forty eight of the 49 sites for which plot-based sampling was undertaken were analysed using the PATN software package (Belbin 1993). One site which sampled young regrowth in a former clearing was excluded from the analysis. The sites were analysed on the basis of full-floristics and foliage cover class scores using the Bray-Curtis dissimilarity measure with the flexible UPGMA (unweighted pair group arithmetic averaging) strategy and a slightly negative (-0.1) beta value.

Results

Introduction

A total of 758 vascular plant taxa have been recorded for Booti Booti NP and Yahoo NR in the present and earlier surveys (Appendix 1). Exotics account for approximately

14% of the flora (104 taxa), although the total number of introduced taxa could be increased with closer examination of disturbed sites (e.g. road verges, picnic areas, former clearings). Disturbed sites were not systematically sampled in the present survey. Further sampling of native vegetation is also likely to increase the number of records of cryptic taxa such as terrestrial orchids.

Of the 654 native taxa known for the reserves, approximately 83% were recorded during fieldwork for the present survey. A similar percentage of native taxa (approximately 78%) is listed in the earlier study of Booti Booti SRA by de Castro Lopo (1980), which includes rainforest records by Clough (1979).

As derived from air photo interpretation and ground survey, 46 plant communities and other vegetation types have been mapped for Booti Booti NP and Yahoo NR (Table 1). This mapping, at a scale of 1: 25 000, is presented as a separate sheet (located in back pocket). The vegetation map is also stored in a GIS maintained by the NSW National Parks and Wildlife Service, both at the Hunter District office (Raymond Terrace) and the Northern Zone office (Coffs Harbour).

In the following discussion each of the plant communities recognised for Booti Booti NP and Yahoo NR is described in terms of its structure, floristic composition, general habitat characteristics, community relations, extent and distribution. This information was compiled using the results of both the plot-based sampling and the fieldwork for vegetation map production. For rainforest communities other than those dominated by *Choricarpia leptopetala*, the descriptions of floristic composition and structure also incorporate information provided by de Castro Lopo (1980), Dodkin (1978) and Floyd (1990, undated).

The distribution of each plant community elsewhere in northern NSW is discussed, primarily by reference to vegetation mapping for other coastal reserves to the north of Booti Booti NP (Fig. 2). Equivalent vegetation types as recognised in other studies are also given where known.

Table 1. Plant communities of Booti Booti National Park and Yahoo Nature Reserve.

The plant communities are named after dominant indicator species of the tallest (dominant) stratum. Five-digit numeric codes are used for mapping purposes to identify individual plant communities. The first four digits of each code identify the formation, subformation and community. A fifth digit (shown in brackets) is used on the vegetation map to signify the crown cover range of the tallest stratum in each polygon: 1 = mid-dense to dense (e.g. open to closed forest); 2 = very sparse to sparse (e.g. open woodland to woodland). Missing codes apply to plant communities not found in Booti Booti NP or Yahoo NR.

* Exotic taxa are prefixed with an asterisk.

Plant Community	Structure	Map Code
FORMATION: forest and woodland		**0000-4999**
Subtropical rainforest		**0000-0499**
Livistona australis	simple, tall to very tall closed fan palm forest	0003(1)
Littoral rainforest		**0500-0999**
Cupaniopsis anacardioides	simple, notophyll-microphyll, low to tall closed forest	0502(1)

Plant Community	Structure	Map Code
Drypetes deplanchei-Sarcomelicope simplicifolia subsp. *simplicifolia-Cassine australis* var. *australis-Podocarpus elatus*	simple, notophyll-microphyll, low to very tall closed forest	0505(1)
Dry rainforest		**1000-1499**
Ficus spp.-*Streblus brunonianus-Dendrocnide* spp.-*Cassine australis* var. *australis*	simple, notophyll, mid-high to tall closed forest	1003(1)
Choricarpia leptopetala	simple, notophyll, low to tall closed forest	1004(1)
Mangrove forest and woodland		**2500-2999**
Avicennia marina subsp. *australasica*	low to mid-high open woodland and woodland	2502(2)
Wet sclerophyll forest		**3000-3499**
Lophostemon confertus	mid-high to very tall, open to closed forest	3002(1)
Eucalyptus grandis	very tall open to closed forest	3004(1)
Eucalyptus pilularis	very tall open to closed forest	3006(1)
Eucalyptus microcorys	very tall open to closed forest	3007(1)
Eucalyptus tereticornis	mid-high to very tall, open to closed forest	3011(1)
Eucalyptus fergusonii subsp. *fergusonii*	tall to very tall, open to closed forest	3012(1)
Corymbia maculata-Eucalyptus fergusonii subsp. *fergusonii-E. acmenoides*	very tall open to closed forest	3013(1)
Dry sclerophyll forest and woodland		**3500-3999**
Eucalyptus pilularis	tall to very tall, open to closed forest	3504(1)
Eucalyptus microcorys	mid-high to very tall, open to closed forest	3508(1)
Eucalyptus tereticornis	mid-high to tall, open woodland to closed forest	3512(1) 3512(2)
Allocasuarina littoralis	low open to closed forest	3513(1)
Angophora costata	mid-high to very tall, open woodland to closed forest	3522(1) 3522(2)
Eucalyptus pilularis-Angophora costata	tall to very tall, woodland to closed forest	3556(1) 3556(2)
Corymbia maculata-Eucalyptus fergusonii subsp. *fergusonii-E. acmenoides*	mid-high to tall, open to closed forest	3559(1)
Eucalyptus tereticornis-E. microcorys	mid-high to very tall, open to closed forest	3560(1)
Angophora floribunda	low to mid-high, open to closed forest	3561(1)
Corymbia maculata	tall to very tall, open to closed forest	3562(1)
Swamp sclerophyll forest and woodland		**4000-4499**
Melaleuca quinquenervia	mid-high to very tall, open woodland to closed forest	4003(1) 4003(2)
Casuarina glauca	mid-high to very tall, open woodland to closed forest	4005(1) 4005(2)
Eucalyptus robusta-Melaleuca quinquenervia	mid-high to very tall, open woodland to closed forest	4098(1) 4098(2)
Melaleuca quinquenervia-Casuarina glauca	mid-high to very tall, open woodland to closed forest	4099(1) 4099(2)
FORMATION: mallee forest and woodland		**5000-5199**
Dry sclerophyll mallee forest and woodland		**5000-5099**

Plant Community	Structure	Map Code
Eucalyptus pilularis	very tall to extremely tall, mallee woodland and open mallee woodland	5002(2)
Swamp sclerophyll mallee forest and woodland		**5100-5199**
Eucalyptus robusta	very tall to extremely tall, mallee woodland and open mallee woodland	5102(2)
FORMATION: shrubland (scrub)		**5200-5599**
Rain-shrubland		**5200-5299**
Choricarpia leptopetala	simple, notophyll, tall to very tall closed shrubland	5203(1)
Dry sclerophyll shrubland		**5400-5499**
Banksia aemula	tall to very tall, open to closed shrubland	5402(1)
Melaleuca armillaris	very tall closed shrubland	5404(1)
Leptospermum laevigatum	tall to very tall closed shrubland	5410(1)
**Chrysanthemoides monilifera* subsp. *rotundata-Acacia sophorae*	mid-high to tall closed shrubland	5411(1)
Swamp sclerophyll shrubland		**5500-5599**
Melaleuca quinquenervia	tall to very tall, sparse to open shrubland	5506(2)
FORMATION: heathland		**5800-6099**
Dry heathland		**5800-5899**
Banksia aemula-Allocasuarina simulans	mid-high to tall closed heathland	5804(1)
Intermediate dry heathland	mid-high to tall closed heathland	5899(1)
Graminoid clay heathland		**5900-5999**
Banksia spinulosa var. *collina-Allocasuarina littoralis-Hakea teretifolia -Ptilothrix deusta-Themeda australis*	low to mid-high closed heathland	5905(1)
Wet heathland		**6000-6099**
Banksia oblongifolia-Leptospermum liversidgei-Sporadanthus interruptus-Sprengelia sprengelioides-Xanthorrhoea fulva	mid-high to tall closed heathland	6002(1)
FORMATION: chenopod shrubland		**6100-6199**
Sarcocornia quinqueflora subsp. *quinqueflora-Sporobolus virginicus*	dwarf to low, open to closed chenopod shrubland/tussock grassland	6102(1)
FORMATION: tussock grassland		**6200-6299**
Spinifex sericeus	low to mid-high, sparse to closed tussock grassland	6202(1) 6202(2)
FORMATION: sod grassland		**6300-6399**
Themeda australis	low to tall closed sod grassland	6302(1)
FORMATION: sedgeland		**6400-6499**
Baumea juncea	mid-high to tall closed sedgeland	6402(1)
Leptocarpus tenax-Baloskion pallens-Schoenus brevifolius	tall to very tall closed sedgeland	6403(1)
FORMATION: rushland		**6500-6599**
Juncus kraussii subsp. *australiensis*	tall to very tall closed rushland	6502(1)
Phragmites australis	very tall closed rushland	6503(1)

Plant community descriptions

Rainforest

Rainforest vegetation covers approximately 17% of Booti Booti NP and Yahoo NR, where it is found on both Carboniferous strata and unconsolidated Quaternary sediments. Five rainforest communities have been recognised for the reserves, and these represent the dry rainforest and subtropical rainforest subformations distinguished by Floyd (1990), with the latter subformation including littoral rainforest. Approximately one third of the native vascular taxa known for the reserves are found in the rainforests.

***Livistona australis* subtropical rainforest (map code 00031).**

Area: 44 ha in Booti Booti NP and Yahoo NR.

Structure: simple, tall to very tall closed fan palm forest.

Floristic composition: *Livistona australis* dominates the tallest stratum (Fig. 4), although *Casuarina glauca*, *Melaleuca quinquenervia*, *Eucalyptus robusta* and *Lophostemon confertus* may be minor associates (< 10%) or emergent (generally < 5%). Understorey species include *Calochlaena dubia*, *Christella dentata*, *Entolasia marginata*, *Livistona australis*, *Oplismenus aemulus* and *Viola hederacea*, although the immediate ground surface is often largely unvegetated due to shading and litter accumulation.

Habitat and community relations: Primarily occurs on sandy Quaternary sediments along broad open depressions, although also extends into gullies on sedimentary bedrock. Grades into swamp sclerophyll forest, and also into other rainforest communities.

Equivalent vegetation types: Forms part of an *Archontophoenix-Livistona* suballiance circumscribed for NSW by Floyd (1990), and also falls within the broader 'Palm' forest type (No. 7) of the Forestry Commission of NSW (1989). A related *Livistona australis* 'woodland' has been reported for south-eastern Queensland (Elsol & Dowling 1978, McDonald & Elsol 1984).

Distribution in northern New South Wales: Present in Broadwater NP and Hat Head NP. The broader *Archontophoenix-Livistona* suballiance of Floyd (1990) is found in several North Coast reserves, both near and inland of the coastline.

Fig. 4. Subtropical rainforest (simple, tall to very tall closed fan palm forest) dominated by *Livistona australis* (community 00031), with blackened stems from a fire in the 1994/95 fire season. The immediate ground surface is often largely unvegetated due to shading and litter accumulation.

Cupaniopsis *anacardioides* littoral rainforest (map code 05021).

Area: 11.5 ha in Booti Booti NP, with additional small areas included in a Foredune Complex map unit.

Structure: simple, notophyll-microphyll, low to tall closed forest.

Floristic composition: *Cupaniopsis anacardioides* is characteristic of the equivalent suballiance circumscribed by Floyd (1990), although other tree species which may be locally subsidiary to co-dominant in Booti Booti NP include *Acmena smithii*, *Alectryon coriaceus*, *Banksia integrifolia* subsp. *integrifolia* (which may be more or less emergent), *Drypetes deplanchei*, *Endiandra sieberi*, *Glochidion ferdinandi* var. *ferdinandi*, *Livistona australis*, *Mischocarpus pyriformis* subsp. *pyriformis*, *Planchonella australis* and *Syzygium oleosum*. Vines include *Cissus antarctica*, *Geitonoplesium cymosum*, *Jasminum volubile* and *Stephania japonica* var. *discolor*.

Habitat and community relations: Found in siliceous sand on sheltered aspects of foredune systems, generally quite close to beach fronts. Replaced by other Foredune Complex communities on more exposed aspects.

Equivalent vegetation types: Named after the equivalent suballiance No. 17 of Floyd (1990), and forms part of the broader forest type No. 24 'Tuckeroo' (Forestry Commission of NSW 1989). A comparable *Acronychia imperforata-Cupaniopsis anacardioides* closed forest is recognised for south-eastern Queensland (McDonald & Elsol 1984).

Distribution in northern New South Wales: The *Cupaniopsis anacardioides* suballiance of Floyd (1990) extends along the North Coast of NSW where it is reserved in Bundjalung NP, Yuraygir NP, Hat Head NP, Crowdy Bay NP, Myall Lakes NP, Brunswick Heads NR, Broken Head NR, Iluka NR, Moonee Beach NR, Bundagen FR, Limeburners Creek NR, Sea Acres NR and Kattang NR. Additional areas outside of the reserve system are protected under SEPP 26-Littoral Rainforest.

Drypetes *deplanchei-Sarcomelicope simplicifolia* subsp. *simplicifolia-Cassine australis* var. *australis-Podocarpus elatus* littoral rainforest (map code 05051).

Area: 120 ha in Booti Booti NP where found on Booti Hill and Cape Hawke. Additional minor stands are included in a Headland Complex map unit.

Structure: simple, notophyll-microphyll, low to very tall closed forest.

Floristic composition: *Drypetes deplanchei*, *Sarcomelicope simplicifolia* subsp. *simplicifolia*, *Cassine australis* var. *australis* and *Podocarpus elatus* are characteristic dominants of the equivalent suballiance circumscribed by Floyd (1990), although other species which may be locally subsidiary to co-dominant in Booti Booti NP include *Austromyrtus bidwillii*, *Baloghia inophylla*, *Dysoxylum fraserianum*, *Euroschinus falcata* var. *falcata*, *Heritiera actinophylla* and *Olea paniculata*. Vines include *Arthropteris tenella* and *Cissus antarctica*. *Platycerium bifurcatum* is an abundant epiphyte.

Habitat and community relations: Found on relatively steep, boulder-strewn hillslopes across a range of aspects, although these are predominantly easterly to south-easterly. The sedimentary bedrock is composed of greywacke and tuffaceous sandstone (Floyd 1990). The community is extensive on the southern section of Cape Hawke, but tends to be replaced by *Choricarpia leptopetala* dry rainforest (code 10041) on the northern section where the northerly aspects are perhaps less sheltered and more fire-prone.

Equivalent vegetation types: Named after the equivalent suballiance No. 19 of Floyd (1990), and forms part of the broader forest type No. 25 'Headland Brush Box' (Forestry Commission of NSW 1989).

Distribution in northern New South Wales: Floyd (1990) reports the distribution of the suballiance as extending from Gap Beach (Hat Head NP) to Myall Lakes on the NSW North Coast, with a less representative occurrence also present in Royal NP on the Central Coast.

***Ficus* spp.-*Streblus brunonianus-Dendrocnide* spp.-*Cassine australis* var. *australis* dry rainforest (map code 10031).**

Area: Occurs on Yahoo NR, and on Booti and Earps Islands in Booti Booti NP. The total area is 7 ha.

Structure: simple, notophyll, mid-high to tall closed forest.

Floristic composition: *Cassine australis* var. *australis*, *Dendrocnide photinophylla*, *Ficus rubiginosa* and *Streblus brunonianus* are some of the characteristic dominants of the equivalent suballiance circumscribed by Floyd (1990), although other species which may be locally subsidiary to

co-dominant in Booti Booti NP and Yahoo NR include *Austromyrtus bidwillii*, *Clerodendrum tomentosum*, *Drypetes deplanchei*, *Olea paniculata* and *Planchonella australis*. Vine species include **Anredera cordifolia*, *Cissus antartica*, **Ipomoea cairica*, *Jasminum volubile* and *Malaisia scandens*.

Habitat and community relations: Occurs on boulder outcrops of islands in Wallis Lake. The bedrock is sedimentary, or more specifically tuffaceous sandstone for Yahoo Island (Floyd 1990). The community can be fringed by swamp sclerophyll forest, and at one location adjoins *Livistona australis* subtropical rainforest.

Equivalent vegetation types: Named after the equivalent suballiance No. 23 of Floyd (1990), and forms part of the broader forest type No. 22 'Yellow Tulipwood' (Forestry Commission of NSW 1989).

Distribution in northern New South Wales: The *Ficus* spp.-*Streblus brunonianus-Dendrocnide* spp.-*Cassine australis* var. *australis* suballiance occurs disjunctly along the North Coast of NSW, and continues further south to Milton (Floyd 1990). Other coastal or island reserves of the North Coast in which the suballiance is present are Myall Lakes NP, John Gould Island NR and Snapper Island NR.

***Choricarpia leptopetala* dry rainforest (map code 10041).**

Area: 99 ha in Booti Booti NP where restricted to Cape Hawke.

Structure: simple, notophyll, low to tall closed forest.

Floristic composition: *Choricarpia leptopetala* dominates the tallest stratum, although *Drypetes deplanchei* and *Lophostemon confertus* may be minor to subsidiary associates (up to 30%), with *L. confertus* becoming more or less emergent at some locations. Understorey and vine species include *Gahnia melanocarpa*, *Notelaea longifolia* forma *intermedia*, *Rapanea variabilis* and *Smilax australis*, although the immediate ground surface may be largely unvegetated due to shading and the presence of extensive rock outcrops.

Habitat and community relations: Extensive on boulder-strewn hillslopes and hillcrests in the northern section of Cape Hawke, particularly on north to north-easterly aspects. At these locations the geology is sedimentary. The community is reduced to the shrubland equivalent (code 52031) on more exposed aspects, and is replaced by *Drypetes deplanchei-Sarcomelicope simplicifolia* subsp. *simplicifolia-Cassine australis* var. *australis-Podocarpus elatus* rainforest (code 05051) along gullies or southerly aspects which are presumably more sheltered and less fire-prone.

Equivalent vegetation types: Named after the *Choricarpia leptopetala* suballiance circumscribed by Floyd (1990), and falls within the broader 'Myrtle' forest type (No. 23) of the Forestry Commission of NSW (1989).

Distribution in northern New South Wales: The *Choricarpia leptopetala* suballiance of Floyd (1990) extends disjunctly along the North Coast of NSW, with limited areas also present on the Central Coast. The suballiance is not known for coastal reserves to the north of Booti Booti NP.

Mangrove woodland

Mangrove vegetation is of very limited extent in Booti Booti NP and Yahoo NR where it occupies approximately 0.15% of the total area. A single community is present, and this is dominated by *Avicennia marina* subsp. *australasica*.

***Avicennia marina* subsp. *australasica* mangrove woodland (map code 25022).**

Area: 2.5 ha in Booti Booti NP and Yahoo NR, with stands in the latter reserve too small to map at a scale of 1: 25 000.

Structure: low to mid-high open woodland and woodland.

Floristic composition: *Avicennia marina* subsp. *australasica* dominates. *Aegiceras corniculatum* is an uncommon understorey shrub. The immediate ground surface is either unvegetated apart from pneumatophores, or else supports lower saltmarsh species such as *Sporobolus virginicus*.

Habitat and community relations: Found on interbedded Quaternary sediments of intertidal flats in the Wallis Lake estuary. Often grades landward into *Sarcocornia quinqueflora* subsp. *quinqueflora-Sporobolus virginicus* chenopod shrubland/tussock grassland where inundation by high tides does not occur on a daily basis.

Distribution in northern New South Wales: Occurs in Bundjalung NP, Yuraygir NP, Hat Head NP, Crowdy Bay NP, Ballina NR, Richmond River NR and Limeburners Creek NR. Additional areas outside of the reserve system are designated as Coastal Wetland under SEPP 14.

Equivalent vegetation types: *Avicennia marina* subsp. *australasica* mangrove forest and woodland is widespread along the NSW coast (Beadle 1981, Adam et al. 1988, West et al. 1984), and extends into Queensland (Batianoff & Elsol 1989, Dowling & McDonald 1982, Durrington 1977). The community forms part of forest type No. 33, 'Mangrove' (Forestry Commission of NSW 1989).

Wet sclerophyll forest

Seven wet sclerophyll forest communities have been recognised for Booti Booti NP. As for rainforest, wet sclerophyll forest is found on both Carboniferous strata and unconsolidated Quaternary sediments. Floristically, the wet sclerophyll forests and rainforests of the reserves have much in common. To illustrate this point, approximately half of the native vascular taxa known for the rainforests are also found in wet sclerophyll forests, primarily in understorey strata.

***Lophostemon confertus* wet sclerophyll forest (map code 30021).**

Area: 5.5 ha in Booti Booti NP where restricted to Booti Hill and Charlotte Head.

Structure: mid-high to very tall, open to closed forest.

Floristic composition: *Lophostemon confertus* dominates the tallest stratum, although *Eucalyptus microcorys* may be a minor associate (< 10%). Understorey and vine species include *Cryptocarya rigida*, *Doodia aspera*, *Lastreopsis decomposita*, *Livistona australis* and *Smilax australis*.

Habitat and community relations: Occurs on south-east to south-west facing hillslopes where the bedrock is sedimentary. Associates with rainforest and *Eucalyptus grandis* wet sclerophyll forest. Replaced by *Eucalyptus pilularis* dry sclerophyll forest on aspects which are likely to be more fire-prone.

Distribution in northern New South Wales: Present in Broadwater NP, Bundjalung NP, Yuraygir NP, Hat Head NP, Iluka NR and Lake Innes NR, although generally as small stands.

Equivalent vegetation types: *Lophostemon confertus* reaches its southern distribution limit in the Hunter River valley on the lower North Coast of NSW (Harden 1991). The community falls within the somewhat broader forest type No. 53 ('Brush Box'), which extends along the coast and escarpment of north-eastern NSW (Forestry Commission of NSW 1989). The community also occurs in south-eastern Queensland (Durrington 1977, Elsol 1991, McDonald & Whiteman 1979, Young & McDonald 1989).

***Eucalyptus grandis* wet sclerophyll forest (map code 30041).**

Area: 8 ha in Booti Booti NP on or near Booti Hill.

Structure: very tall open to closed forest.

Floristic composition: *Eucalyptus grandis* dominates the tallest stratum, although *Corymbia intermedia*, *Eucalyptus microcorys*, *E. pilularis*, *Livistona australis*, *Lophostemon confertus* and *Melaleuca quinquenervia* may be present as minor associates (< 10%) or occasionally subsidiary (up to 30%). Understorey species include *Acacia binervata*, *Baloghia inophylla*, *Cupaniopsis anacardioides*, *Gahnia clarkei*, **Lantana camara* and *Livistona australis*.

Habitat and community relations: Generally occurs along sheltered hillslopes and gullies where the bedrock is sedimentary, although also extends onto sandy Quaternary sediments near the base of Booti Hill. Associates with *Lophostemon confertus* and *Eucalyptus microcorys* wet sclerophyll forests, and at one location also adjoins littoral rainforest. Commonly replaced by *Eucalyptus pilularis* dry sclerophyll forest on less sheltered aspects.

Distribution in northern New South Wales: Present in Broadwater NP, Bundjalung NP, Crowdy Bay NP, Moonee Beach NR, Limeburners Creek NR and Lake Innes NR, although generally as very limited stands.

Equivalent vegetation types: *Eucalyptus grandis* reaches its southern distribution limit in the Newcastle area on the lower North Coast (Chippendale 1988, Harden 1991). The community extends north from here along the NSW coast (Beadle 1981, Forestry Commission of NSW 1989, as forest type No. 48 'Flooded Gum'), and is also found in south-eastern Queensland (Elsol & Dowling 1978, McDonald & Whiteman 1979).

***Eucalyptus pilularis* wet sclerophyll forest (map code 30061).**

Area: 7 ha on Booti Hill in Booti Booti NP.

Structure: very tall open to closed forest.

Floristic composition: The tallest stratum is floristically variable, although *Eucalyptus pilularis* accounts for 50% or more of total crown cover.

Subsidiary or co-dominant species include *Eucalyptus grandis*, *E. microcorys*, *E. propinqua* and *Lophostemon confertus*. Understorey species include *Citriobatus pauciflorus*, *Cryptocarya microneura*, *C. rigida*, *Doodia aspera* and *Lophostemon confertus*. Vine species include *Cissus hypoglauca* and *Smilax australis*.

Habitat and community relations: Occurs along south to south-west facing hillslopes and gullies where the bedrock is sedimentary. Grades into *Eucalyptus pilularis* dry sclerophyll forest on less sheltered aspects, with boundaries between the two communities no doubt maintained by fire.

Distribution in northern New South Wales: Found in Bundjalung NP, Yuraygir NP, Hat Head NP, Dooragan NP, Crowdy Bay NP and Lake Innes NR. Also present in many state forests, and some conservation reserves away from the seaboard.

Equivalent vegetation types: *Eucalyptus pilularis* extends north from the Eden district (Harden 1991), although the community is more extensive further north in coastal NSW (Beadle 1981, Forestry Commission of NSW 1989, as forest type No. 36 'Moist Blackbutt'). *Eucalyptus pilularis* wet sclerophyll forest also occurs in south-eastern Queensland (Elsol 1991, McDonald & Elsol 1984, McDonald & Whiteman 1979).

***Eucalyptus microcorys* wet sclerophyll forest (map code 30071).**

Area: 5.5 ha in Booti Booti NP where restricted to Booti Hill and Elizabeth Beach.

Structure: very tall open to closed forest.

Floristic composition: *Eucalyptus microcorys* dominates the tallest stratum, although *Lophostemon confertus* may be a minor associate (< 10%) or subsidiary (up to 30%). Understorey species include *Cryptocarya rigida*, *Diospyros pentamera*, *Doodia aspera*, *Gahnia melanocarpa* and *Livistona australis*.

Habitat and community relations: The main stands occupy south to south-west facing hillslopes where the bedrock is sedimentary. At a single location with little or no aspect the community is found on sandy Quaternary sediments. On less sheltered aspects the community is replaced by *Eucalyptus pilularis* dry sclerophyll forest. At one location the community adjoins rainforest.

Distribution in northern New South Wales: *Eucalyptus microcorys* has a coastal distribution which extends north from the upper Central Coast of NSW into south-eastern Queensland (Chippendale 1988, Harden 1991). The only other coastal reserve on the North Coast of NSW in which the community appears to be present is Lake Innes NR. The equivalent forest type No. 45, 'Tallowwood' is considered to have a restricted distribution in state forests on the North Coast (Forestry Commission of NSW 1989).

Equivalent vegetation types: The Forestry Commission of NSW (1989) recognises a 'Tallowwood' forest type (No. 45).

***Eucalyptus tereticornis* wet sclerophyll forest (map code 30111).**

Area: 7 ha in Booti Booti NP where restricted to the northern section of Cape Hawke.

Structure: mid-high to very tall, open to closed forest.

Floristic composition: *Eucalyptus tereticornis* dominates. Understorey and vine species include *Cassine australis* var. *australis*, *Choricarpia leptopetala*, *Drypetes deplanchei*, *Gahnia aspera*, *Jasminum volubile* and *Notelaea longifolia* forma *intermedia*.

Habitat and community relations: Occurs on north and north-east facing hillslopes where the bedrock is sedimentary. Replaced by rainforest on increasingly sheltered aspects, and by Headland Complex vegetation on aspects which are more exposed to onshore winds.

Distribution in northern New South Wales: Not known from other coastal reserves in northern NSW, although the dry sclerophyll equivalent (code 35121) is present in Bundjalung NP, Yuraygir NP, Hat Head NP, Limeburners Creek NR and Lake Innes NR.

Equivalent vegetation types: *Eucalyptus tereticornis* forest and woodland extends along the NSW coast and onto the Central Western Slopes (Benson 1989, Forestry Commission of NSW 1989, as forest type No. 92 'Forest Red Gum'), although these occurrences would generally lack a mesophytic understorey. Similar forests and woodlands also occur in south-eastern Queensland (Durrington 1977, Elsol 1991, Elsol & Dowling 1978, Young & McDonald 1989).

***Eucalyptus fergusonii* subsp. *fergusonii* wet sclerophyll forest (map code 30121).**

Area: 4 ha in Booti Booti NP where restricted to the southern end of Cape Hawke.

Structure: tall to very tall, open to closed forest.

Floristic composition: *Eucalyptus fergusonii* subsp. *fergusonii* dominates the tallest stratum, although *E. acmenoides* may be a minor associate (< 10%) or subsidiary (up to 30%). Understorey species include *Diospyros australis*, *Gahnia melanocarpa*, **Lantana camara*, *Lomandra longifolia*, *Macrozamia communis* and *Notelaea longifolia* forma *intermedia*.

Habitat and community relations: Occurs on south and south-east facing hillslopes where the bedrock is sedimentary.

Distribution in northern New South Wales: No other occurrences of the community are known. *Eucalyptus fergusonii* subsp. *fergusonii* has a very sporadic distribution which was previously thought to extend from Morisset to Bulahdelah (Harden 1991).

Equivalent vegetation types: Possibly forms part of forest type No. 84, 'Ironbark' (Forestry Commission of NSW 1989).

***Corymbia maculata-Eucalyptus fergusonii* subsp. *fergusonii-Eucalyptus acmenoides* wet sclerophyll forest (map code 30131).**

Area: 3 ha in Booti Booti NP where restricted to the southern end of Cape Hawke.

Structure: very tall open to closed forest.

Floristic composition: *Corymbia maculata*, *Eucalyptus fergusonii* subsp. *fergusonii* and *Eucalyptus acmenoides* dominate. Understorey species include *Doodia aspera*, *Livistona australis*, *Lomandra longifolia*, *Notelaea longifolia* forma *intermedia*, *Poa labillardieri* and *Pittosporum undulatum*.

Habitat and community relations: Occurs on a south facing hillslope where the bedrock is sedimentary. Grades into *Corymbia maculata-Eucalyptus fergusonii* subsp. *fergusonii-E. acmenoides* dry sclerophyll forest on less sheltered aspects, with boundaries between the two communities no doubt maintained by fire. Replaced by rainforest on increasingly sheltered aspects.

Distribution in northern New South Wales: No other occurrences of the community are known. *Eucalyptus fergusonii* subsp. *fergusonii* has a very sporadic distribution which was previously thought to extend from Morisset to Bulahdelah (Harden 1991).

Equivalent vegetation types: Possibly forms part of forest type No. 74, 'Spotted Gum-Ironbark/Grey Gum' (Forestry Commission of NSW 1989).

Dry sclerophyll forest and woodland

Ten dry sclerophyll forest and woodland communities are recognised for the reserves, and these are found on both sedimentary bedrock and unconsolidated Quaternary sediments. The dry sclerophyll forest and woodland communities share many tallest stratum species in common with the wet sclerophyll forests (e.g. *Corymbia maculata*, *Eucalyptus pilularis*, *E. microcorys*, *E. tereticornis*). Understorey species which are common to the range of dry sclerophyll forests and woodlands include *Imperata cylindrica* var. *major*, *Lomandra longifolia* and *Themeda australis*.

***Eucalyptus pilularis* dry sclerophyll forest (map code 35041).**

Area: 87 ha in Booti Booti NP where restricted to Booti Hill and Charlotte Head.

Structure: tall to very tall, open to closed forest.

Floristic composition: The tallest stratum is floristically variable, although *Eucalyptus pilularis* accounts for 50% or more of total crown cover (Fig. 5). Subsidiary or co-dominant species include *Angophora costata*, *Corymbia intermedia*, *C. maculata*, *Eucalyptus carnea*, *E. microcorys*, *E. propinqua*, *E. resinifera* subsp. *hemilampra* and *E. tereticornis*. Understorey species include *Acacia longifolia*, *Allocasuarina torulosa*, *Imperata cylindrica* var. *major*, *Poa labillardieri* and *Themeda australis*.

Habitat and community relations: Largely restricted to south-westerly aspects on hillslopes where the bedrock is sedimentary. Grades into wet sclerophyll forests of *Eucalyptus grandis*, *E. microcorys* and *E. pilularis* on more sheltered aspects. Often replaced by dry sclerophyll forest dominated by *Eucalyptus microcorys* and/or *E. tereticornis* on seaward aspects.

Distribution in northern New South Wales: Occurs in Broadwater NP, Bundjalung NP, Yuraygir NP, Hat Head NP, Dooragan NP, Crowdy Bay NP, Limeburners Creek NR and Lake Innes NR.

Fig. 5. Dry sclerophyll forest (tall to very tall, open to closed forest) dominated by *Eucalyptus* pilularis (community 35041). Understorey species include *Acacia longifolia, Allocasuarina torulosa, Imperata cylindrica* var. *major, Poa labillardieri* and *Themeda australis*.

Equivalent vegetation types: *Eucalyptus pilularis* extends north from the Eden district on the South Coast of NSW (Harden 1991), and the community is widespread throughout coastal NSW (Beadle 1981, Forestry Commission of NSW 1989, as forest type No. 37 'Dry Blackbutt'). The community also occurs in south-eastern Queensland (Elsol 1991, McDonald & Whiteman 1979).

***Eucalyptus microcorys* dry sclerophyll forest (map code 35081).**

Area: 15.5 ha in Booti Booti NP where restricted to Booti Hill.

Structure: mid-high to very tall, open to closed forest.

Floristic composition: *Eucalyptus microcorys* dominates the tallest stratum, although *Angophora floribunda, Eucalyptus carnea, E. pilularis, E. resinifera* subsp. *hemilampra* and *E. tereticornis* are minor associates (< 10%). Understorey species include *Acacia maidenii, Imperata cylindrica* var. *major, Poa labillardieri* and *Themeda australis*.

Habitat and community relations: Occurs on hillslopes across a range of aspects where the bedrock is sedimentary. Often grades into *Eucalyptus tereticornis* dry sclerophyll forest or *E. tereticornis-E. microcorys* dry sclerophyll forest (see comment under community 35601). Replaced by *Eucalyptus pilularis* dry sclerophyll forest on aspects facing away from the sea.

Distribution in northern New South Wales: Present in Bundjalung NP, Crowdy Bay NP and Lake Innes NR. The equivalent forest type No. 45, 'Tallowwood' is considered to have a restricted distribution in state forests on the North Coast (Forestry Commission of NSW 1989).

Equivalent vegetation types: *Eucalyptus microcorys* has a coastal distribution which extends north from the upper Central Coast of NSW into south-eastern Queensland (Chippendale 1988, Harden 1991). The equivalent forest type No. 45 is typically a wet sclerophyll forest (Forestry Commission of NSW 1989).

***Eucalyptus tereticornis* dry sclerophyll forest and woodland (map codes 35121, 35122).**

Area: 16 ha in Booti Booti NP where largely restricted to Booti Hill and Charlotte Head.

Structure: mid-high to tall, open woodland to closed forest.

Floristic composition: *Eucalyptus tereticornis* dominates the tallest stratum, although *Casuarina glauca*, *Eucalyptus microcorys*, *E. pilularis* and *E. propinqua* may be present as minor associates (< 10%). Understorey species include *Acacia maidenii*, *Imperata cylindrica* var. *major*, *Lomandra longifolia* and *Themeda australis*.

Habitat and community relations: Generally occurs on north to north-easterly aspects of hillslopes where the bedrock is sedimentary, although at one location found on a flat formed from Quaternary sediments. Often grades into *Eucalyptus microcorys* or *E. tereticornis-E. microcorys* dry sclerophyll forest (see comment under community 35601). Replaced by *Eucalyptus pilularis* dry sclerophyll forest on aspects facing away from the sea.

Distribution in northern New South Wales: Present in Bundjalung NP, Yuraygir NP, Hat Head NP, Limeburners Creek NR and Lake Innes NR, although typically as limited stands.

Equivalent vegetation types: Extends along the coast of NSW, and onto the Central Western Slopes (Benson 1989, Forestry Commission of NSW 1989, as forest type No. 92 'Forest Red Gum'). Also occurs in south-eastern Queensland (Durrington 1977, Elsol 1991, Elsol & Dowling 1978, Young & McDonald 1989).

***Allocasuarina littoralis* dry sclerophyll forest (map code 35131).**

Area: Occupies 2.5 ha on Booti Hill and Charlotte Head in Booti Booti NP, with additional small areas included in a Headland Complex map unit.

Structure: low open to closed forest.

Floristic composition: *Allocasuarina littoralis* dominates the tallest stratum, although *Angophora floribunda* and *Eucalyptus tereticornis* may be minor associates (< 10%). Understorey species include **Chrysanthemoides monilifera* subsp. *rotundata*, *Entolasia marginata* and *Lomandra longifolia*.

Habitat and community relations: Occupies north-easterly to easterly hillslopes and low hillslopes close to the sea where the bedrock is sedimentary. Often grades into dry sclerophyll forest of *Eucalyptus pilularis*, *E. microcorys* or *E. tereticornis* on less exposed aspects.

Distribution in northern New South Wales: Present in Yuraygir NP, Hat Head NP, Crowdy Bay NP, Richmond River NR, Limeburners Creek NR, Lake Innes NR and Kattang NR.

Equivalent vegetation types: Has a scattered distribution along the North Coast of NSW, and extends to the Central Coast (Benson & Howell 1990). Benson (1989) also reports a community dominated by *Allocasuarina littoralis* for the Northern Tablelands of NSW, and an equivalent *A. littoralis* 'scrub' (Batianoff & Elsol 1989) or 'thicket' (Durrington 1977) occurs in south-eastern Queensland. *Allocasuarina littoralis* 'scrub' is also known for coastal situations in Victoria (Lunt 1998).

***Angophora costata* dry sclerophyll forest and woodland (map codes 35221, 35222).**

Area: 7 ha in Booti Booti NP where found on Charlotte Head and the southern end of Cape Hawke.

Structure: mid-high to very tall, open woodland to closed forest.

Floristic composition: *Angophora costata* dominates the tallest stratum, although *Eucalyptus pilularis* may be a minor associate (< 10%). Understorey species include **Lantana camara*, *Macrozamia communis*, *Pteridium esculentum* and *Xanthorrhoea macronema*.

Habitat and community relations: Occurs in podzolised sand which mantles the sedimentary bedrock of lower hillslopes. Grades into *Eucalyptus pilularis-Angophora costata* dry sclerophyll forest (code 35561), and also adjoins rainforest.

Distribution in northern New South Wales: *Angophora costata* is endemic to NSW where it has a predominantly coastal distribution south from the Evans River (Bale 1992, Harden 1991), although

with some major range disjunctions on coastal sand masses (e.g. between the Hastings and Macleay Rivers). To the north of Booti Booti NP, the community occurs in Yuraygir NP and Crowdy Bay NP.

Equivalent vegetation types: Reported for the Myall Lakes area on the lower North Coast of NSW (Myerscough & Carolin 1986), and also for the Central Coast (Benson 1986). The Forestry Commission of NSW (1989) has a 'Smoothbarked Apple' forest type (No. 105) for stands dominated by *Angophora costata* or *A. leiocarpa* (the latter species was formerly included in *A. costata* s. lat.).

***Eucalyptus pilularis-Angophora costata* dry sclerophyll forest and woodland (map codes 35561, 35562).**

Area: 68.5 ha in Booti Booti NP where found on sand masses.

Structure: tall to very tall, woodland to closed forest.

Floristic composition: The tallest stratum is floristically variable, although *Eucalyptus pilularis* accounts for 50% or more of total crown cover. *Angophora costata* is either a minor associate (< 10%), or subsidiary to co-dominant. Understorey species include *Banksia serrata* (which may be more or less continuous in height with the tallest stratum), *Gonocarpus teucrioides*, *Persoonia levis*, *P. linearis*, *Pteridium esculentum*, *Themeda australis* and *Xanthorrhoea macronema*.

Habitat and community relations: Found on well-drained podzolised sands which usually occur as dunes or beach ridges, but occasionally as a mantle over hillslopes where the underlying bedrock is sedimentary. Replaced by swamp sclerophyll forest as soil drainage deteriorates, and by *Eucalyptus pilularis* dry sclerophyll forest (community 35041) on bedrock hills and low hills where a sand mantle is lacking. Adjoins rainforest at some locations.

Distribution in northern New South Wales: Not known for coastal reserves to the north of Booti Booti NP, although a related *Eucalyptus pilularis-Angophora costata/E. gummifera/E. planchoniana* community (code 35061) is found on sand masses in Bundjalung NP, Yuraygir NP and Crowdy Bay NP. To the south of Booti Booti NP, the community occurs in Myall Lakes NP (Myerscough & Carolin 1986).

Equivalent vegetation types: Falls within the broader forest type No. 41, which is commonly referred to as 'Sandhill Blackbutt' (Forestry Commission of NSW 1989). *Eucalyptus pilularis* is ubiquitous in this forest type, with one or two of *Corymbia gummifera*, *C. intermedia*, *Angophora floribunda* and *A. costata* present as associates in varying combinations. Forms part of a *Eucalyptus pilularis-Angophora costata* suballiance circumscribed by Beadle (1981).

***Corymbia maculata-Eucalyptus fergusonii* subsp. *fergusonii-Eucalyptus acmenoides* dry sclerophyll forest (map code 35591).**

Area: 25 ha in Booti Booti NP where restricted to the southern end of Cape Hawke.

Structure: mid-high to tall, open to closed forest.

Floristic composition: *Corymbia maculata*, *Eucalyptus fergusonii* subsp. *fergusonii* and *Eucalyptus acmenoides* dominate. Understorey species include *Lomandra longifolia*, *Poa labillardieri* and *Themeda australis*.

Habitat and community relations: Occurs on sedimentary bedrock of hillslopes and hillcrests with a predominantly north to north-westerly aspect. Grades into *Corymbia maculata-Eucalyptus fergusonii* subsp. *fergusonii-E. acmenoides* wet sclerophyll forest on more sheltered aspects, with boundaries between the two communities no doubt maintained by fire.

Distribution in northern New South Wales: No other occurrences of the community are known. *Eucalyptus fergusonii* subsp. *fergusonii* has a very sporadic distribution which was previously thought to extend from Morisset to Bulahdelah (Harden 1991).

Equivalent vegetation types: Possibly forms part of forest type No. 74, 'Spotted Gum-Ironbark/Grey Gum' (Forestry Commission of NSW 1989).

***Eucalyptus tereticornis-Eucalyptus microcorys* dry sclerophyll forest (map code 35601).**

Area: 29 ha in Booti Booti NP where restricted to Booti Hill.

Structure: mid-high to very tall, open to closed forest.

Floristic composition: *Eucalyptus tereticornis* and *E. microcorys* dominate the tallest stratum, although *Angophora floribunda*, *Corymbia intermedia* and *E. grandis* may be a minor associates (< 10%) or subsidiary (up to 30%). Understorey species include *Acacia maidenii*, *Imperata cylindrica* var. *major*, *Lomandra longifolia*, *Poa labillardieri* and *Themeda australis*.

Habitat and community relations: Occurs on northerly, north-westerly and south-westerly aspects of hillslopes where the bedrock is sedimentary. The community might be considered transitional between dry sclerophyll forest dominated by *Eucalyptus microcorys* (code 35081), and that dominated by *Eucalyptus tereticornis* (code 35121). All three communities occur in close proximity to each other.

Distribution in northern New South Wales: Other occurrences of the community are not known.

Equivalent vegetation types: Not known, although comments made for dry sclerophyll forest in which *Eucalyptus microcorys* (code 35081) or *Eucalyptus tereticornis* (code 35121) is dominant have some relevance.

***Angophora floribunda* dry sclerophyll forest (map code 35611).**

Area: Only present as small stands on Booti Hill in Booti Booti NP, and here all occurrences are included in a Headland Complex map unit.

Structure: low to mid-high, open to closed forest.

Floristic composition: *Angophora floribunda* dominates the tallest stratum, although *Eucalyptus microcorys* may be a minor associate (< 10%). Understorey species include *Breynia oblongifolia*, *Imperata cylindrica* var. *major*, **Lantana camara* and *Pratia purpurascens*.

Habitat and community relations: Occurs on relatively exposed hillslopes close to sea cliffs where the bedrock is sedimentary. Closely associates with other headland vegetation. Replaced by dry sclerophyll forests of *Eucalyptus microcorys*, *E. pilularis* and *E. tereticornis* on less exposed aspects.

Distribution in northern New South Wales: *Angophora floribunda* reaches the northern limit of its coastal distribution in the Hastings River valley (Leach 1986). The community is not known to be reserved elsewhere on the lower North Coast, although a related community (code 35251) in which *Angophora floribunda* associates with *Corymbia intermedia* and *Banksia serrata* is present as limited stands on Quaternary sand in Limeburners Creek NR, Lake Innes NR, Kattang NR and Crowdy Bay NP.

Equivalent vegetation types: Forms part of the broader 'Rough-barked Apples' forest type No. 129 (Forestry Commission of NSW 1989). Forest and woodland in which *Angophora floribunda* dominates has been reported for sedimentary bedrock in Ku-ring-gai Chase National Park on the Central Coast of NSW (Le Brocque & Buckney 1994).

***Corymbia maculata* dry sclerophyll forest (map code 35621).**

Area: 8.5 ha in Booti Booti NP where restricted to Booti Hill.

Structure: tall to very tall, open to closed forest.

Floristic composition: *Corymbia maculata* dominates the tallest stratum, although *C. intermedia* may be a minor associate (< 10%). Understorey species include **Chrysanthemoides monilifera* subsp. *rotundata*, *Commelina cyanea*, *Imperata cylindrica* var. *major*, *Poa labillardieri* and *Themeda australis*.

Habitat and community relations: Largely restricted to hillcrests and higher hillslopes, in shallow, stoney soil derived from sedimentary rock. Replaced by *Eucalyptus pilularis* dry sclerophyll forest on sheltered south-westerly hillslopes, and by *E. tereticornis* and *E. microcorys* dry sclerophyll forests on hillslopes with a more northerly aspect. Adjoins rainforest at one location.

Distribution in northern New South Wales: *Corymbia maculata* has a mainly coastal distribution which extends south from the Manning River valley on the mid North Coast (Hill & Johnson 1995), and the community is found in a number of state forests across this distribution (Forestry Commission of NSW 1989).

Equivalent vegetation types: Falls within the *Corymbia maculata* s. lat. alliance of Beadle (1981), and the 'Spotted Gum' (*C. variegata*/*C. maculata*/ *C. henryi*) forest type (No. 70) of the Forestry Commission of NSW (1989), both of which are described as widespread in coastal NSW.

Swamp sclerophyll forest and woodland

The swamp sclerophyll forest and woodland communities of Booti Booti NP and Yahoo NR are best developed on Quaternary sediments in areas with impeded drainage. Three species, *Casuarina glauca*, *Eucalyptus robusta* and *Melaleuca quinquenervia* characterise the tallest stratum, and the understorey supports various helophytes.

Swamp sclerophyll forest and woodland occupies approximately 15% of the reserves, and supports about 11% of the total number of native vascular taxa.

***Melaleuca quinquenervia* swamp sclerophyll forest and woodland (map codes 40031, 40032).**

Area: 156 ha in Booti Booti NP where the largest stands are found in the vicinity of Green Point.

Structure: mid-high to very tall, open woodland to closed forest.

Floristic composition: *Melaleuca quinquenervia* dominates the tallest stratum, although *Casuarina glauca* and *Eucalyptus robusta* may be present as minor associates (< 10%). Understorey species include *Baloskion tetraphyllum* subsp. *meiostachyum* and *Blechnum indicum*.

Habitat and community relations: Generally occupies broad swamps near sea level where the peaty soils overlie sandy Quaternary sediments. Occasionally extends onto seepage areas associated with low hillslopes and gullies over sedimentary bedrock. Commonly grades into swamp sclerophyll forest and woodland of *Eucalyptus robusta* or *Casuarina glauca* (see vegetation types 40981/2 and 40991/2). Also adjoins a range of other vegetation types including sedgeland, heathland and shrubland.

Distribution in northern New South Wales: Present in all major coastal reserves of northern NSW which sample vegetation on Quaternary sediments. Many additional areas outside the reserve system are designated as Coastal Wetland under SEPP 14.

Equivalent vegetation types: *Melaleuca quinquenervia* has a coastal distribution in NSW north from Botany Bay on the Central Coast (Harden 1991). The community is particularly widespread on the North Coast, although extensive areas have been cleared for agriculture and urban development (Forestry Commission of NSW (1989), as part of forest type No. 31 'Paperbark', Goodrick 1970, Pressey & Griffith 1992). The community is also found in south-eastern Queensland (Batianoff & Elsol 1989, Dowling & McDonald 1976, Durrington 1977, Elsol & Dowling 1978).

***Casuarina glauca* swamp sclerophyll forest and woodland (map codes 40051, 40052).**

Area: 46.5 ha in Booti Booti NP and Yahoo NR, with additional small areas included in a Headland Complex map unit.

Structure: mid-high to very tall, open woodland to closed forest.

Floristic composition: *Casuarina glauca* dominates the tallest stratum, although *Melaleuca quinquenervia* may be present as a minor associate (< 10%). Understorey and vine species include *Baumea juncea*, **Ipomoea cairica* and *Juncus kraussii* subsp. *australiensis*, although the immediate ground surface is often largely unvegetated due to shading and litter accumulation.

Habitat and community relations: Grows in muddy estuarine sediments of flats associated with the Wallis Lake estuary. Limited areas also occur on exposed aspects of coastal hills and headlands. Often forms a landward fringe to saltmarsh vegetation or, in the absence of the latter, lines the shores of Wallis Lake and its islands. Grades into *Melaleuca quinquenervia* swamp sclerophyll forest and woodland under less saline conditions.

Distribution in northern New South Wales: Found in Bundjalung NP, Yuraygir NP, Hat Head NP, Crowdy Bay NP, Ballina NR, Richmond River NR, Moonee Beach NR, Limeburners Creek NR, Lake Innes NR, Kattang NR and Khappinghat NR. Additional areas outside of the reserve system are designated as Coastal Wetland under SEPP 14.

Equivalent vegetation types: Extends along coastal NSW, although floodplain occurrences have been extensively cleared (Adam et al. 1985, Forestry Commission of NSW (1989), as forest type No. 32 'Swamp Oak', Goodrick 1970). Also present in south-eastern Queensland (Batianoff & Elsol 1989, Dowling & McDonald 1976, Elsol & Dowling 1978, McDonald & Whiteman 1979).

***Eucalyptus robusta-Melaleuca quinquenervia* swamp sclerophyll forest and woodland (map codes 40981, 40982).**

Area: 28.5 ha in Booti Booti NP.

Structure: mid-high to very tall, open woodland to closed forest.

Floristic composition: *Eucalyptus robusta* and *Melaleuca quinquenervia* dominate the tallest

stratum (Fig. 6). Understorey species include *Baloskion tetraphyllum* subsp. *meiostachyum*, *Blechnum indicum* and *Gahnia clarkei*.

Habitat and community relations: Occupies broad swamps near sea level where the peaty soils are formed over sandy Quaternary sediments. Often grades into *Melaleuca quinquenervia* swamp forest and woodland, or *Eucalyptus robusta* swamp mallee woodland. Also adjoins *Livistona australis* rainforest.

Equivalent vegetation types: This vegetation type category is used for stands of swamp sclerophyll forest and woodland in which the shift in dominance from *Eucalyptus robusta* to *Melaleuca quinquenervia* occurs over areas which are too small to separate at the mapping scale employed. Such shifts in dominance may be a response to subtle changes in microtopography or drainage, although in some situations *Eucalyptus robusta* and *Melaleuca quinquenervia* seemingly co-occur. This mixing of the two species has also been noted for the Myall Lakes area (Myerscough & Carolin 1986). The vegetation type could be considered a composite of forest type No. 30 'Swamp Mahogany' and forest type No. 31 'Paperbark' (Forestry Commission of NSW 1989).

Distribution in northern New South Wales: Occurs in Broadwater NP, Bundjalung NP, Yuraygir NP, Hat Head NP, Myall Lakes NP (Myerscough & Carolin 1986), Moonee Beach NR, Limeburners Creek NR and Lake Innes NR. Also found on areas of crown or freehold land (e.g. Evans Head, the Newrybar sand plain near Lennox Head, Frogalla Swamp north of Tuncurry).

Fig. 6. Swamp sclerophyll forest (tall open forest) dominated by *Melaleuca quinquenervia* and *Eucalyptus robusta* (map code 40981), recovering from a crown fire in late January 1997. *Blechnum indicum* is conspicuous in the ground stratum.

***Melaleuca quinquenervia-Casuarina glauca* swamp sclerophyll forest and woodland (map codes 40991, 40992).**

Area: 18 ha in Booti Booti NP and Yahoo NR.

Structure: mid-high to very tall, open woodland to closed forest.

Floristic composition: *Melaleuca quinquenervia* and *Casuarina glauca* dominate the tallest stratum. Understorey species include *Baumea juncea*, *Eriochloa procera*, *Hemarthria uncinata*, *Lobelia alata* and *Zoysia macrantha*.

Habitat and community relations: Occurs on flats associated with the Wallis Lake estuary where the soils are derived from Quaternary sediments. Limited areas also occur on hillslopes close to the sea where the bedrock is sedimentary. Often associates with other swamp forest and woodland communites, as well as *Livistona australis* rainforest.

Equivalent vegetation types: This vegetation type category is used for stands of swamp sclerophyll forest and woodland in which the shift in dominance from *Melaleuca quinquenervia* to *Casuarina glauca* occurs over areas which are too small to separate at the mapping scale employed. Such shifts in dominance may be a response to subtle changes in microtopography or hydrology, although in some situations *Melaleuca quinquenervia* and *Casuarina glauca* seemingly co-occur. This mixing of the two species has also been noted for the Myall Lakes area (Myerscough & Carolin 1986). The vegetation type could be considered a composite of forest type No. 31 'Paperbark' and forest type No. 32 'Swamp Oak' (Forestry Commission of NSW 1989).

Distribution in northern New South Wales: Present in Bundjalung NP, Yuraygir NP, Hat Head NP, Myall Lakes NP (Myerscough & Carolin 1986), Ballina NR, Moonee Beach NR, Limeburners Creek NR, Lake Innes NR and Kattang NR. Also present at numerous locations outside the reserve system, and many of these occurrences are designated as Coastal Wetland under SEPP 14.

Mallee woodland

Limited stands of mallee woodland are found in Booti Booti NP where two communities have been recognised. One community dominated by *Eucalyptus robusta* is found in poorly drained depressions. *Eucalyptus pilularis* dominates the second community, and this is found in a well-drained situation.

***Eucalyptus pilularis* dry sclerophyll mallee woodland (map code 50022).**

Area: 4 ha along The Lakes Way in Booti Booti NP.

Structure: very tall to extremely tall, mallee woodland and open mallee woodland.

Floristic composition: *Eucalyptus pilularis* dominates the tallest stratum, although *Angophora costata* may be a minor associate (< 10%). Understorey species include *Banksia aemula*, *Coleocarya gracilis*, *Hypolaena fastigiata* and *Lomandra glauca*.

Habitat and community relations: Found in a well-drained sand podzol, on the lower slope of a dune where partly sheltered from onshore winds. Replaced by *Banksia aemula-Allocasuarina simulans* dry heathland on more exposed aspects.

Distribution in northern New South Wales: Appears to have a scattered distribution on sand masses of the NSW North Coast, with other occurrences in Broadwater NP, Bundjalung NP, Yuraygir NP, Crowdy Bay NP and Lake Innes NR.

Equivalent vegetation types: None known, although in some respects the community could be considered a structural variant of *Eucalyptus pilularis-Angophora costata* dry sclerophyll forest and woodland (codes 35561/2).

***Eucalyptus robusta* swamp sclerophyll mallee woodland (map code 51022).**

Area: 30.5 ha in Booti Booti NP.

Structure: very tall to extremely tall, mallee woodland and open mallee woodland.

Floristic composition: *Eucalyptus robusta* dominates. Understorey species include *Baloskion tetraphyllum* subsp. *meiostachyum*, *Dianella caerulea*, *Imperata cylindrica* var. *major* and *Leptospermum polygalifolium*.

Habitat and community relations: Found in peaty soils along open depressions associated with beach ridges and dunes. Often grades upslope into *Banksia aemula* dry sclerophyll shrubland or *B. aemula-Allocasuarina simulans* dry heathland.

Distribution in northern New South Wales: Limited areas occur in Broadwater NP, Crowdy Bay NP, Moonee Beach NR and Lake Innes NR. Small stands also occur on areas of crown or freehold land (e.g. Evans Head, and the Newrybar sand plain near Lennox Head).

Equivalent vegetation types: Although the range of *Eucalyptus robusta* extends along much of the NSW coast (Harden 1991), this mallee community appears to have a very scattered distribution (e.g. Murray 1989, Pressey & Griffith 1992).

Shrubland

Shrubland vegetation is typically greater than 2 m in height, and supports a tallest stratum dominated by woody plants which are multistemmed at or near the base. Occasionally shrublands are less than 2 m high (cf. heathland) where dominated by species which are better classified as shrubs rather than heath shrubs using the criteria of Walker and Hopkins (1984). Shrublands are found in a range of habitats throughout Booti Booti NP, and the following six communities have been recognised for rain-shrubland, dry sclerophyll shrubland and swamp sclerophyll shrubland subformations.

***Choricarpia leptopetala* rain-shrubland (map code 52031).**

Area: 3 ha in Booti Booti NP where restricted to the northern section of Cape Hawke.

Structure: simple, notophyll, tall to very tall closed shrubland.

Floristic composition: *Choricarpia leptopetala* is more or less mono-dominant. Understorey species include *Gahnia aspera* and *Gymnostachys anceps*, although the immediate ground surface is largely unvegetated due to shading and the presence of extensive rock outcrops.

Habitat and community relations: Occupies east and north-east facing hillslopes where exposed to onshore winds. The substrate is sedimentary rock, and this outcrops extensively as boulders. Grades into the forest equivalent, *Choricarpia leptopetala* dry rainforest, on less exposed aspects.

Equivalent vegetation types: A structural variant of the *Choricarpia leptopetala* dry rainforest suballiance circumscribed by Floyd (1990), which extends to the Central Coast of NSW. The suballiance forms part of forest type No. 23, 'Myrtle' (Forestry Commission of NSW 1989).

Distribution in northern New South Wales: The *Choricarpia leptopetala* suballiance of Floyd (1990) extends disjunctly along the North Coast of NSW, although it is not present in other coastal reserves to the north of Booti Booti NP.

***Banksia aemula* dry sclerophyll shrubland (map code 54021).**

Area: 72 ha in Booti Booti NP.

Structure: tall to very tall, open to closed shrubland.

Floristic composition: *Banksia aemula* is the characteristic dominant of the tallest stratum. *Boronia pinnata*, *Leptospermum polygalifolium*, *L. trinervium*, *Melaleuca nodosa*, *Pteridium esculentum* and other species form a somewhat continuous understorey, certain of which (e.g. *L. polygalifolium*, *L. trinervium*) may merge and associate with *B. aemula* in the absence of fire for long periods. At some locations *Eucalyptus robusta* is present as a scattered tree mallee emergent (< 5%).

Habitat and community relations: Grows in sand podzol soils of beach ridges and dunes. Replaced by *Banksia aemula-Allocasuarina simulans* dry heathland on more exposed aspects. Often replaced downslope by wet heathland, swamp sclerophyll forest, or *Eucalyptus robusta* swamp sclerophyll mallee woodland.

Distribution in northern New South Wales: Occurs in Broadwater NP, Bundjalung NP, Yuraygir NP, Hat Head NP, Crowdy Bay NP, Moonee Beach NR and Limeburners Creek NR. Also present on areas of freehold or crown land (e.g. the Newrybar sand plain near Lennox Head).

Equivalent vegetation types: Widespread on the North Coast of NSW, and extends to the Central Coast (Benson & Howell 1990). Also occurs in south-eastern Queensland (Batianoff & Elsol 1989, Dowling & McDonald 1976, Durrington 1977).

***Melaleuca armillaris* dry sclerophyll shrubland (map code 54041).**

Area: 6.5 ha on headlands in Booti Booti NP, with additional small areas included in a Headland Complex map unit.

Structure: very tall closed shrubland.

Floristic composition: *Melaleuca armillaris* is more or less mono-dominant in the tallest stratum. Understorey species include **Chrysanthemoides monilifera* subsp. *rotundata*, *Gahnia aspera* and *Oplismenus imbecillis*, although the immediate ground surface may be largely unvegetated due to heavy shading and the presence of extensive rock outcrops.

Habitat and community relations: Found on relatively steep, south to south-east facing aspects of hillslopes close to the sea. The bedrock is sedimentary, and this outcrops extensively. Associates with several other Headland Complex communities.

Distribution in northern New South Wales: Although *Melaleuca armillaris* has a range which extends into Queensland (Harden 1991), it is not known from coastal headlands of NSW any further north than the Forster area.

Equivalent vegetation types: To the south of Booti Booti NP, the community has been reported for Seal Rocks (Clough 1979). It is also likely to occur elsewhere on the lower North Coast of NSW, as in Myall Lakes NP (Myerscough & Carolin 1986, as part of a 'headland thicket' map unit) and Tomaree NP (Benson 1981, as part of a 'closed-scrub' map unit).

***Leptospermum laevigatum* dry sclerophyll shrubland (map code 54101).**

Area: 26 ha in Booti Booti NP, with additional areas included in Foredune Complex and Headland Complex map units.

Structure: tall to very tall closed shrubland.

Floristic composition: *Leptospermum laevigatum* is more or less mono-dominant in the tallest stratum. Understorey species include **Chrysanthemoides monilifera* subsp. *rotundata*, *Dianella caerulea*, *Lepidosperma concavum* and *Lomandra longifolia*, although the immediate ground surface may be largely unvegetated due to heavy shading.

Habitat and community relations: Grows in well drained siliceous sand of foredunes close to the sea, with limited occurrences also extending onto exposed aspects of bedrock headlands. Associates with a number of other Foredune Complex and Headland Complex communities, although generally replaced by **Chrysanthemoides monilifera* subsp. *rotundata-Acacia sophorae* shrubland on more exposed aspects along beach fronts.

Distribution in northern New South Wales: Shrubland or forest stands of *Leptospermum laevigatum* occur in Hat Head NP, Crowdy Bay NP, Limeburners Creek NR and Kattang NR. *Leptospermum laevigatum* reaches its natural northern limit of distribution in the Nambucca Heads area (Harden 1991), although it has been planted further north following sand mining.

Equivalent vegetation types: *Leptospermum laevigatum* is a characteristic species of foredune shrublands (and low forests) along parts of southern Australia, including the Central and South Coasts of NSW (Beadle 1981, Bennett 1994).

****Chrysanthemoides monilifera* subsp. *rotundata-Acacia sophorae* dry sclerophyll shrubland (map code 54111).**

Area: Occurs in Booti Booti NP where only mapped as part of a Foredune Complex map unit.

Structure: mid-high to tall closed shrubland.

Floristic composition: **Chrysanthemoides monilifera* subsp. *rotundata* dominates the community, with *Acacia sophorae* present as a subsidiary to minor species (from 30% to < 10%). The immediate ground surface is largely unvegetated due to shading.

Habitat and community relations: Grows in well-drained siliceous sand of Holocene foredunes just above the general zone of influence of high seas. Replaced by *Spinifex sericeus* tussock grassland at lower elevations approaching mean high water level. Often replaced landward by *Leptospermum laevigatum* dry sclerophyll shrubland.

Distribution in northern New South Wales: This community, or the variant *Acacia sophorae* shrubland (code 54081), occurs in all coastal reserves of northern NSW where foredune vegetation is represented.

Equivalent vegetation types: A variant of *Acacia sophorae* shrubland, and only differs in the degree of displacement of *A. sophorae* by the exotic shrub **Chrysanthemoides monilifera* subsp. *rotundata*. *Acacia sophorae* is widespread as a shrubland dominant along the NSW coast (Beadle 1981). *Acacia sophorae* shrubland is also found in south-eastern Queensland (W. McDonald, Queensland Herbarium pers. comm.), although *A. sophorae* reaches its northern distribution limit at Point Arkwright near Coolum (Batianoff & Elsol 1989).

***Melaleuca quinquenervia* swamp sclerophyll shrubland (map code 55062).**

Area: 2.5 ha in Booti Booti NP near the shore of Wallis Lake.

Structure: tall to very tall, sparse to open shrubland.

Floristic composition: *Melaleuca quinquenervia* dominates. Understorey species include *Baumea articulata*, *B. juncea*, *Fimbristylis ferruginea*, *Juncus kraussii* subsp. *australiensis* and *Schoenoplectus litoralis*.

Habitat and community relations: Grows in small swamps near the shore of Wallis Lake where the soil consists of peat over Quaternary sediments. Grades into swamp sclerophyll forest, presumably where drainage improves.

Distribution in northern New South Wales: Occurs in Broadwater NP, Bundjalung NP, Yuraygir NP, Hat Head NP and Kattang NR, and also present on areas of freehold or crown land (e.g. the Newrybar sand plain near Lennox Head). Most occurrences are of limited extent.

Equivalent vegetation types: Appears to have a limited distribution in NSW, although heathlands in which *Melaleuca quinquenervia* is dominant or co-dominant are recognised for south-eastern Queensland (Batianoff & Elsol 1989, Dowling & McDonald 1976, Durrington 1977).

Heathland

Heathland vegetation is less than 2 m in height, and supports a range of woody species, particularly from the families Proteaceae, Myrtaceae, Epacridaceae, Fabaceae and Rutaceae. Heath shrubs often, but not always, have ericoid leaves. Heathland vegetation is widespread in Booti Booti NP but absent from Yahoo NR. Most of the heathlands in Booti Booti NP are found on podzolised Quaternary sands, although a small area of graminoid clay heathland on Charlotte Head is growing in shallow soil derived from sedimentary rock. Approximately 23% of the total number of native vascular taxa recorded for the reserves are found in heathland.

***Banksia aemula-Allocasuarina simulans* dry heathland (map code 58041).**

Area: 89 ha along The Lakes Way in Booti Booti NP.

Structure: mid-high to tall closed heathland.

Floristic composition: *Banksia aemula* and *Allocasuarina simulans* are the characteristic dominants, although other species which may be subsidiary or co-dominant include *Acacia ulicifolia*, *Isopogon anemonifolius*, *Monotoca scoparia* and *Ricinocarpus pinifolius* (Fig. 7).

Habitat and community relations: Grows in sand podzol soils of dunes, on aspects exposed to prevailing onshore winds. Replaced by *Banksia aemula* dry sclerophyll shrubland on more sheltered aspects, and by wet heathland or sedgeland where soil drainage deteriorates.

Distribution in northern New South Wales: *Allocasuarina simulans* is endemic to the Forster-Nabiac area (Harden 1990), and the community is only known for Booti Booti NP.

Equivalent vegetation types: None known, although a related *Banksia aemula-Allocasuarina littoralis* dry heathland community (code 58031) occurs on the NSW North Coast (e.g. in Broadwater NP, Yuraygir NP, Hat Head NP, Crowdy Bay NP and Kattang NR), as well as in south-eastern Queensland (Batianoff & Elsol 1989). For the Central Coast of NSW, McRae (1990) reports *Allocasuarina distyla* as common in *Banksia aemula* heathland of Bouddi Peninsula. *Allocasuarina simulans* was formerly included in *A. distyla* (*Casuarina distyla*) s. lat.

Intermediate dry heathland (map code 58991).

Area: 26.5 ha in Booti Booti NP.

Structure: mid-high to tall closed heathland.

Floristic composition: Intermediate dry heathland supports a mixture of both dry heathland (58041) and wet heathland (60021) species, for example *Banksia aemula*, *B. oblongifolia*, *Dillwynia floribunda* var. *floribunda*, *Hypolaena fastigiata*, *Leptospermum polygalifolium*, *Sporadanthus interruptus*, *Lomandra glauca* and *Melaleuca nodosa*.

Habitat and community relations: Occurs on podzolised sands of deflated dunes where a shallow watertable is present following periods of high rainfall. Intermediate dry heathland is a feature of very deflated sand masses on the NSW North Coast which display little or no slope and aspect. Where the topography becomes more pronounced, intermediate dry heathland is replaced by dry heathland upslope on dunes and beach ridges, and by wet heathland downslope in swales.

Fig. 7. *Banksia aemula-Allocasuarina simulans* dry heathland (mid-high to tall closed heathland; community 58041) recovering from a severe fire in late January 1997.

Distribution in northern New South Wales: Present in Crowdy Bay NP, Moonee Beach NR and Lake Innes NR. Also found on some areas of freehold or crown land (e.g. the Newrybar sand plain near Lennox Head).

Equivalent vegetation types: For the Myall Lakes area on the lower North Coast of NSW, Myerscough and Carolin (1986) found the boundaries between dry heathland and wet heathland to be somewhat obscure also. Furthermore, for the far North Coast and south-eastern Queensland there are reports of *Banksia aemula* shrubland supporting a ground stratum of 'wet heathland' species in low-lying areas rather than the more typical suite of 'dry heathland' species (Batianoff & Elsol 1989, Griffith 1983).

***Banksia spinulosa* var. *collina-Allocasuarina littoralis-Hakea teretifolia-Ptilothrix deusta-Themeda australis* graminoid clay heathland (map code 59051).**

Area: 2 ha in Booti Booti NP where restricted to the southern section of Charlotte Head.

Structure: low to mid-high closed heathland.

Floristic composition: *Banksia spinulosa* var. *collina*, *Allocasuarina littoralis*, *Hakea teretifolia*, *Ptilothrix deusta* and *Themeda australis* are the characteristic dominants. Other subsidiary to co-dominant species include *Epacris pulchella* and *Gonocarpus tetragynus*. Grasses and sedges form a large component of the above-ground biomass, hence the use of the term 'graminoid'.

Habitat and community relations: Restricted to a steep, south-facing hillslope close to the ocean where exposed to high levels of salt accession. The stoney soil is formed over sedimentary rock. Replaced by forest and woodland on northerly aspects, and also on lower slopes where sand mantles the bedrock. Also adjoins stands of *Melaleuca armillaris* shrubland.

Distribution in northern New South Wales: Not known to occur elsewhere, although closely related communities are discussed below.

Equivalent vegetation types: Forms part of the *Allocasuarina littoralis-Banksia oblongifolia* (syn. *Casuarina littoralis-Banksia aspleniifolia*) 'headland heath' alliance of Beadle (1981). Similar graminoid clay heathland communities are found on headlands

and exposed coastal hills elsewhere on the North Coast of NSW. These include a *Banksia oblongifolia-Allocasuarina littoralis-Hakea teretifolia-Aristida warburgii-Ptilothrix deusta* community (code 59031) on rhyolite in Crowdy Bay NP, a *B. oblongifolia-A. littoralis-H. teretifolia-A. warburgii-Themeda australis* community (code 59041) on adamellite in Hat Head NP and Arakoon SRA, and a *B. oblongifolia-A. littoralis-A. warburgii-P. deusta* community (code 59021) on sedimentary rock in Yuraygir NP. Related communities in which *Allocasuarina littoralis* is replaced by *A. distyla* also occur on the lower North Coast (Benson 1981) and Central Coast (McRae 1990). Similar heathland vegetation is found on trachyte and rhyolite in south-eastern Queensland (Batianoff & Elsol 1989), for example on Mount Coolum (S.J.G. pers.observ. 1999).

Banksia oblongifolia-Leptospermum liversidgei-Sporadanthus interruptus-Sprengelia sprengelioides-Xanthorrhoea fulva wet heathland (map code 60021).

Area: 34.5 ha in Booti Booti NP.

Structure: mid-high to tall closed heathland.

Floristic composition: Floristically variable, although three or more of *Banksia oblongifolia*, *Leptospermum liversidgei*, *Sporadanthus interruptus*, *Sprengelia sprengelioides* and *Xanthorrhoea fulva* usually co-dominate. Other subsidiary or co-dominant species are *Callistemon citrinus*, *Dillwynia floribunda* var. *floribunda*, *Lepidosperma neesii*, *Lepyrodia scariosa* and *Melaleuca nodosa*. The incidence of fire may explain some of the variation in floristic composition, as certain species are obligate seeders (e.g. *Sprengelia sprengelioides*, *Dillwynia floribunda* var. *floribunda*). Under a suitable fire regime, the serotinous obligate seeder *Banksia ericifolia* var. *macrantha* may overtop lower heath shrub species to form a closed shrubland.

Habitat and community relations: Grows in humus podzol and peaty podzol soils of dune swales where humic groundwater remains close to the ground surface for extended periods. Often replaced by *Banksia aemula-Allocasuarina simulans* dry heathland or *Banksia aemula* dry sclerophyll shrubland upslope as soil drainage improves. Replaced by sedgeland downslope where standing water accumulates.

Distribution in northern New South Wales: Found in Broadwater NP, Bundjalung NP, Yuraygir NP, Hat Head NP, Crowdy Bay NP, Myall Lakes NP (Myerscough & Carolin 1986), Moonee Beach NR, Limeburners Creek NR, Lake Innes NR and Khappinghat NR. Also present on some areas of freehold or crown land (e.g. Evans Head, and the Newrybar sand plain near Lennox Head).

Equivalent vegetation types: Widespread over much of the NSW North Coast, extending south to the Myall Lakes area (Myerscough & Carolin 1986). Equivalent communities are also recognised for south-eastern Queensland (Batianoff & Elsol 1989, Clifford & Specht 1979, Durrington 1977, Elsol & Dowling 1978). *Leptospermum liversidgei* reaches its southern distribution limit on the lower North Coast at Port Stephens (McNair 1992), as does *Sporadanthus interruptus* (Harden 1993). The remaining three species after which the community is named extend further south (Harden 1991, 1992).

Chenopod shrubland, tussock grassland and sod grassland

Chenopod shrubland, tussock grassland and sod grassland communities are found in what could be considered extreme habitats along estuaries, sea cliffs and beaches. The following three communities have been recognised for Booti Booti NP, and one is also found in Yahoo NR.

***Sarcocornia quinqueflora* subsp. *quinqueflora-Sporobolus virginicus* chenopod shrubland/tussock grassland (map code 61021).**

Area: 19.5 ha in Booti Booti NP and Yahoo NR, with additional small areas included in a Saltmarsh Complex map unit. Occurrences of the community in Yahoo NR are too small to map discretely at a scale of 1: 25 000.

Structure: dwarf to low, open to closed chenopod shrubland/tussock grassland.

Floristic composition: *Sarcocornia quinqueflora* subsp. *quinqueflora* (a chenopod shrub) and *Sporobolus virginicus* (a tussock grass) can co-exist in mixed stands, or alternatively zonation may occur over short distances (with boundaries gradational, and generally unmappable at the scale employed). Occasionally one or other of the two species is mono-dominant over larger areas. *Casuarina glauca* may be present as a scattered emergent (< 5%).

Habitat and community relations: Found on interbedded Quaternary sediments of tidal flats associated with the Wallis Lake estuary (Fig. 8). Often replaced by *Juncus kraussii* subsp. *kraussii* rushland upslope, and may be replaced by *Avicennia marina* subsp. *australasica* mangrove woodland downslope closer to mean high tide level.

Distribution in northern New South Wales: Present in Bundjalung NP, Yuraygir NP, Hat Head NP, Crowdy Bay NP, Moonee Beach NR, Limeburners Creek NR and Lake Innes NR. Additional areas outside of the reserve system are designated as Coastal Wetland under SEPP 14.

Equivalent vegetation types: This variable community, which could be further subdivided on the basis of relative dominance by the characteristic species (Adam et al. 1988), or else treated as a community complex (Zedler et al. 1995), extends along the NSW coast and into southern Queensland (Adam et al. 1988, Beadle 1981, Dowling & McDonald 1976, Elsol & Dowling 1978).

***Spinifex sericeus* tussock grassland (map codes 62021, 62022).**

Area: Occurs in Booti Booti NP where only mapped as part of a Foredune Complex map unit.

Structure: low to mid-high, sparse to closed tussock grassland.

Floristic composition: *Spinifex sericeus* dominates, although species which may be subsidiary to minor associates (30% to < 10%) include **Cakile maritima*, *Carpobrotus glaucescens*, **Chrysanthemoides monilifera* subsp. *rotundata*, **Conyza bilbaoana*, *Scaevola calendulacea* and *Zoysia macrantha*.

Habitat and community relations: Grows in relatively unstable sands of foredunes just above high water level. Often replaced by **Chrysanthemoides monilifera* subsp. *rotundata*-*Acacia sophorae* shrubland at slightly higher elevations.

Distribution in northern New South Wales: Occurs in all reserves of northern NSW which sample foredune vegetation.

Fig. 8. *Sarcocornia quinqueflora* subsp. *quinqueflora-Sporobolus virginicus* dwarf to low, open to closed chenopod shrubland/tussock grassland (community 61021) on tidal flats associated with the Wallis Lake estuary.

Equivalent vegetation types: Widespread along the NSW coast (Benson 1989), and also extends into south-eastern Queensland (Batianoff & Elsol 1989, Durrington 1977).

***Themeda australis* sod grassland (map code 63021).**

Area: Occurs in Booti Booti NP where only mapped as part of a Headland Complex map unit.

Structure: low to tall closed sod grassland.

Floristic composition: *Themeda australis* is the characteristic dominant, although closely intertwined heath shrubs, sedges and rushes such as *Abildgaardia ovata*, *Lomandra longifolia* and *Pimelea linifolia* may be subsidiary or minor associates (generally < 10%). Species such as *Banksia integrifolia* subsp. *integrifolia*, *Casuarina glauca*, *Isolepis nodosa* and *Westringia fruticosa* may be present as scattered emergents (< 5%).

Habitat and community relations: Occupies very exposed seaward slopes of headlands, in black headland soils (after Parbery 1947) formed from sedimentary rock under high levels of cyclic salt accession. Replaced by a range of other headland forest and shrubland communities on less exposed aspects.

Distribution in northern New South Wales: Found in Bundjalung NP, Yuraygir NP, Hat Head NP, Crowdy Bay NP, Moonee Beach NR, Limeburners Creek NR and Kattang NR. Also present on a number of headlands outside the reserve system (e.g. Evans Head).

Equivalent vegetation types: Widespread on the North Coast of NSW (Griffith 1992, Quint 1982), and extends further south (Adam et al. 1989, Beadle 1981, Benson 1986, Benson & Howell 1990, McRae 1990). Also occurs in south-eastern Queensland (Batianoff & Elsol 1989).

Sedgeland and rushland

The sedgelands of Booti Booti NP and Yahoo NR are dominated by species from the families Cyperaceae and Restionaceae, whereas the rushlands are dominated by either *Juncus kraussii* subsp. *australiensis* or *Phragmites australis*. Two sedgeland communities and two rushland communities are recognised for the reserves. Collectively these communities support approximately 6% of the native vascular taxa known for the reserves.

***Baumea juncea* sedgeland (map code 64021).**

Area: 24 ha in Booti Booti NP and Yahoo NR, with additional small areas included in a Saltmarsh Complex map unit.

Structure: mid-high to tall closed sedgeland.

Floristic composition: *Baumea juncea* dominates. *Sporobolus virginicus* may be present as a shorter but continuous species beneath *B. juncea*. At some locations *Melaleuca quinquenervia* is present as a scattered emergent (< 5%).

Habitat and community relations: Found in solonchak soils of supratidal flats associated with the Wallis Lake estuary. Grades into *Juncus kraussii* subsp. *kraussii* rushland or *Sarcocornia quinqueflora* subsp. *quinqueflora*-*Sporobolus virginicus* chenopod shrubland/tussock grassland downslope closer to mean high tide level. Often grades landward into swamp forest or woodland dominated by *Casuarina glauca* and/or *Melaleuca quinquenervia*.

Distribution in northern New South Wales: Present in Broadwater NP, Bundjalung NP, Yuraygir NP, Hat Head NP, Crowdy Bay NP, Moonee Beach NR, Limeburners Creek NR and Lake Innes NR. Additional areas outside of the reserve system are designated as Coastal Wetland under SEPP 14.

Equivalent vegetation types: Extends along the Central Coast of NSW (Adam et al. 1988, Kratochvil et al. 1973), and also occurs in Victoria (Head 1988) and south-eastern Queensland (Beadle 1981).

***Leptocarpus tenax*-*Baloskion pallens*-*Schoenus brevifolius* sedgeland (map code 64031).**

Area: 36.5 ha in Booti Booti NP, predominantly in the vicinity of Green Point.

Structure: tall to very tall closed sedgeland.

Floristic composition: A floristically variable community. *Leptocarpus tenax*, *Baloskion pallens* and *Schoenus brevifolius* are characteristic dominants, although one (occasionally two) of these may be replaced by such species as *Baumea arthrophylla* and *B. teretifolia*. Certain heath shrubs (e.g. *Callistemon pachyphyllus*, *Melaleuca thymifolia*) can also make a significant contribution to crown cover.

Habitat and community relations: Found in acid peat soils of dunal swamps where standing water is

present for extended periods. Replaced by wet heathland and dry heathland upslope as soil drainage improves.

Distribution in northern New South Wales: Present in Bundjalung NP, Yuraygir NP, Hat Head NP, Crowdy Bay NP, Limeburners Creek NR and Lake Innes NR. Additional areas outside of the reserve system are designated as Coastal Wetland under SEPP 14.

Equivalent vegetation types: The community shares many species in common with a somewhat broader *Empodisma minus* (syn. *Calorophus minor*)-*Leptocarpus tenax* alliance described for south-eastern Queensland and NSW by Beadle (1981). *Leptocarpus tenax*, *Baloskion pallens*, *Schoenus brevifolius* and *Baumea teretifolia* are characteristic of a sedgeland community delineated for Tomaree NP on the lower North Coast of NSW by Bell (1997). A related sedgeland of *Leptocarpus tenax*, *Schoenus brevifolius* and other species has been described for the Gosford-Lake Macquarie area on the Central Coast of NSW (Benson 1986). Similar communities also occur in south-eastern Queensland (Batianoff & Elsol 1989, Dowling & McDonald 1976, Elsol & Dowling 1978).

***Juncus kraussii* subsp. *australiensis* rushland (map code 65021).**

Area: 2.5 ha in Booti Booti NP and Yahoo NR, with additional small areas included in a Saltmarsh Complex map unit.

Structure: tall to very tall closed rushland.

Floristic composition: *Juncus kraussii* subsp. *australiensis* dominates. *Sporobolus virginicus* may be present as a shorter but continuous species beneath *J. kraussii* subsp. *australiensis*. *Casuarina glauca* is sometimes present as a scattered emergent (< 5%).

Habitat and community relations: Found on interbedded Quaternary sediments of supratidal flats associated with the Wallis Lake estuary. Often grades into *Baumea juncea* sedgeland upslope, and into *Sarcocornia quinqueflora* subsp. *quinqueflora*-*Sporobolus virginicus* chenopod shrubland/tussock grassland downslope closer to mean high tide level.

Distribution in northern New South Wales: Found in Broadwater NP, Bundjalung NP, Yuraygir NP, Hat Head NP, Crowdy Bay NP, Moonee Beach NR, Limeburners Creek NR and Lake Innes NR. Additional areas outside of the reserve system are designated as Coastal Wetland under SEPP 14.

Equivalent vegetation types: Widespread on the North Coast of NSW, and extends to the Central and South Coasts (Adam et al. 1988, Beadle 1981, Benson 1986, Goodrick 1970, Kratochvil et al. 1973). Also present in south-eastern Queensland (Batianoff & Elsol 1989, Durrington 1977).

***Phragmites australis* rushland (map code 65031).**

Area: 2 ha in Booti Booti NP and Yahoo NR, with additional small areas included in a Saltmarsh Complex map unit.

Structure: very tall closed rushland.

Floristic composition: *Phragmites australis* dominates. *Baumea juncea*, *Fimbristylis ferruginea* and *Juncus kraussii* subsp. *australiensis* may be present as shorter but continuous species beneath *Phragmites australis*. *Casuarina glauca* can be present as a scattered emergent (< 5%).

Habitat and community relations: Found in solonchak soils of supratidal flats associated with the Wallis Lake estuary. Often grades into *Baumea juncea* sedgeland, and also adjoins swamp sclerophyll forest and woodland.

Distribution in northern New South Wales: Present elsewhere on the mid North Coast in Hat Head NP, Limeburners Creek NR, Lake Innes NR and Khappinghat NR, although generally as very limited stands. Also reported for Myall Lakes NP on the lower North Coast (Myerscough & Carolin 1986). Additional areas outside of the reserve system are designated as Coastal Wetland under SEPP 14.

Equivalent vegetation types: *Phragmites australis* rushland is found on a number of coastal floodplains in northern NSW (Pressey 1981, 1987a,b; Pressey & Griffith 1987), and estuarine occurrences of the community are also reported for NSW by others (e.g. Adam et al. 1988, Brockhoff 1988). A *Phragmites australis* suballiance is recognised by Beadle (1981) for the coast of eastern and south-eastern Australia, and also for some inland rivers and lakes.

Vegetation complexes

Complex map units have been used to delineate groups of plant communities where the individual

communities are too small or intermixed to map separately at a scale of 1: 25 000. The following three complex map units have been applied to foredune, saltmarsh and headland vegetation in Booti Booti NP.

Foredune Complex (map code 90100).

The main constituent communities of the Foredune Complex are *Leptospermum laevigatum* dry sclerophyll shrubland (code 54101), **Chrysanthemoides monilifera* subsp. *rotundata-Acacia sophorae* dry sclerophyll shrubland (code 54111) and *Spinifex sericeus* tussock grassland (codes 62021/2), although limited areas of *Cupaniopsis anacardioides* littoral rainforest (code 05021) and *Melaleuca quinquenervia* swamp sclerophyll forest (code 40031) are also likely.

Other species may also dominate in the Foredune Complex over small areas, for example *Banksia integrifolia* subsp. *integrifolia*, *Carex pumila*, *Lomandra longifolia*, *Scaevola calendulacea* and *Zoysia macrantha*. **Chrysanthemoides monilifera* subsp. *rotundata* is prevalent in the complex, and **Casuarina equisetifolia* subsp. *incana* has been planted at some locations. Much of the complex is regeneration following sand mining.

Saltmarsh Complex (map code 90200).

The main constituent communities of the Saltmarsh Complex are *Sarcocornia quinqueflora* subsp. *quinqueflora-Sporobolus virginicus* chenopod shrubland/tussock grassland (code 61021), *Baumea juncea* sedgeland (code 64021) and *Juncus kraussii* subsp. *australiensis* rushland (code 65021), with small areas of *Avicennia marina* subsp. *australasica* mangrove woodland (code 25022), *Phragmites australis* rushland (code 65031) and unvegetated mudflat also likely.

Other species may dominate in the Saltmarsh Complex over minor localised areas, for example *Paspalum vaginatum* or *Schoenoplectus litoralis*.

Headland Complex (map code 90300).

The main constituent communities of the Headland Complex are *Allocasuarina littoralis* dry sclerophyll forest (code 35131), *Angophora floribunda* dry sclerophyll forest (code 35611), *Casuarina glauca* swamp sclerophyll forest (code 40051), *Melaleuca armillaris* dry sclerophyll shrubland (code 54041) and *Themeda australis* sod grassland (code 63021).

Other communities which are likely to be present in the complex as limited stands are *Livistona australis* subtropical rainforest (code 00031), *Cupaniopsis anacardioides* littoral rainforest (code 05021), *Drypetes deplanchei-Sarcomelicope simplicifolia* subsp. *simplicifolia-Cassine australis* var. *australis-Podocarpus elatus* littoral rainforest (code 05051), *Choricarpia leptopetala* dry rainforest (code 10041), *Melaleuca quinquenervia* swamp sclerophyll forest (code 40031), *Choricarpia leptopetala* rain-shrubland (code 52031) and *Leptospermum laevigatum* dry sclerophyll shrubland (code 54101). On very exposed aspects, forest communities may grade into shrublands.

Other species can dominate in the Headland Complex over small localised areas, for example *Banksia integrifolia* subsp. *integrifolia* or *Westringia fruticosa*. **Chrysanthemoides monilifera* subsp. *rotundata* is prevalent in the complex, and exotic grasses such as **Pennisetum clandestinum* occur as localised infestations.

Miscellaneous map units

Miscellaneous map units are used to identify artificial, disturbed or predominantly unvegetated areas, for example clearings (code 92030), urban development (code 92090) and open water (code 91040). Yahoo NR is in a relatively natural state, although approximately 7% of Booti Booti NP is in a cleared or otherwise disturbed condition (road easements and regenerated mine paths excluded), particularly on the Cape Hawke hill complex.

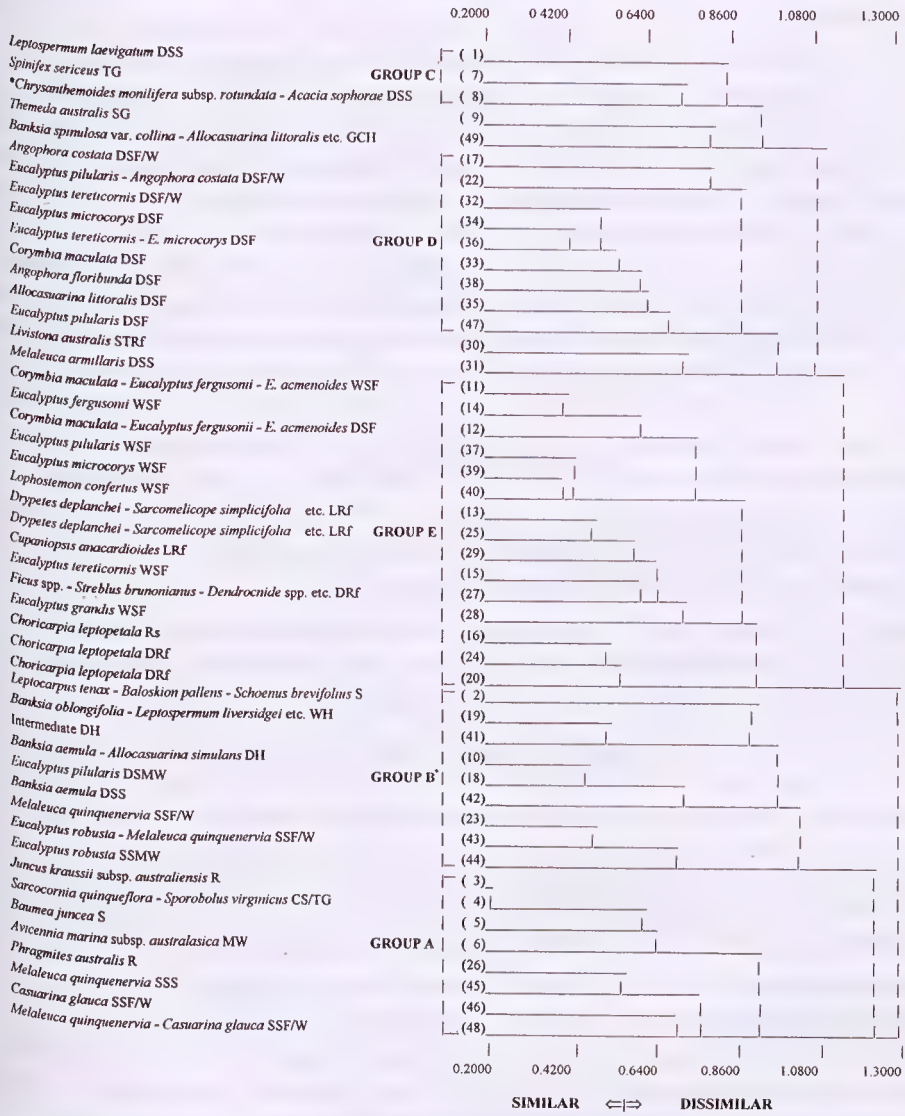
Numerical analysis

The numerical analysis using PATN (Belbin 1993) produced a hierarchical, agglomerative polythetic classification of the 48 plot-based sites. The results are presented as a dendrogram (Fig. 9).

In the interpretation of hierarchical classifications such as the one produced here, any decision as to the selection of the most meaningful number of final floristic groups is still subjective and largely rests on the current level of ecological understanding (see Kent & Coker 1992). This dilemma is further compounded by a lack of sample site replication, as is the case in the present study other than for *Drypetes deplanchei-Sarcomelicope simplicifolia* subsp. *simplicifolia-Cassine australis* var. *australis-Podocarpus elatus* littoral rainforest (Sites 13 and 25) and *Choricarpia leptopetala* dry rainforest (Sites 20 and 24).

If, for arguments sake, the number of floristic groups were to be constrained at the level for which the replicate rainforest sites combine (dissimilarity coefficient of approximately 0.55 on Fig. 9), a number of other sites also merge. These groups of merging sites include:

- Sites 32, 34 and 36: *Eucalyptus tereticornis* dry sclerophyll forest/woodland (DSF/W), *E. microcorys* DSF and *E. tereticornis-E. microcorys* DSF, all of which have obvious tallest stratum affinities, and many understorey species in common;
- Sites 11 and 14: *Corymbia maculata-Eucalyptus fergusonii* subsp. *fergusonii-E. acmenoides* wet sclerophyll forest (WSF) and *E. fergusonii* subsp. *fergusonii* WSF, which have tallest stratum affinities, and many understorey species in common;
- Sites 37, 39 and 40: *Eucalyptus pilularis* WSF, *E. microcorys* WSF and *Lophostemon confertus* WSF, all of which share many common understorey species, with the tallest stratum species also interchanging as subsidiary or minor associates rather than dominants (e.g. *E. microcorys* as a subsidiary or minor tallest stratum species in *E. pilularis* WSF and *L. confertus* WSF);
- Sites 19 and 41: *Banksia oblongifolia-Leptospermum liversidgei-Sporadanthus interruptus-Sprengelia sprengelioides-Xanthorrhoea fulva* wet heathland and intermediate dry heathland, which are topographically contiguous, and have many species in common;
- Sites 10 and 18: *Banksia aemula-Allocasuarina simulans* dry heathland and *Eucalyptus pilularis* dry sclerophyll mallee woodland, with the latter having an understorey of typical 'dry heathland' species;
- Sites 23 and 43: *Melaleuca quinquenervia* swamp sclerophyll forest/woodland (SSF/W) and *Eucalyptus robusta-M. quinquenervia* SSF/W, which have tallest stratum affinities, and many understorey species in common;
- Sites 3 and 4: *Juncus kraussii* subsp. *australiensis* rushland and *Sarcocornia quinqueflora* subsp. *quinqueflora-Sporobolus virginicus* chenopod shrubland/tussock grassland, which are often topographically contiguous, with *S. virginicus* extending beneath *J. kraussii* subsp. *australiensis*;



ABBREVIATIONS:

DSS = Dry Sclerophyll Shrubland
TG = Tussock Grassland
SG = Sod Grassland
GCH = Graminoid Clay Heathland
DSF/W = Dry Sclerophyll Forest/Woodland
STRf = Subtropical Rainforest
WSF = Wet Sclerophyll Forest
LRf = Littoral Rainforest
DRf = Dry Rainforest
Rs = Rain-shrubland
S = Sedgeland
WH = Wet Heathland
DH = Dry Heathland
DSMW = Dry Sclerophyll Mallee Woodland
SSF/W = Swamp Sclerophyll Forest/Woodland
SSMW = Swamp Sclerophyll Mallee Woodland
R = Rushland
CS = Chenopod Shrubland
MW = Mangrove Woodland
SSS = Swamp Sclerophyll Shrubland

Fig. 9. Dendrogram showing the relationships between 48 sites in Booti Booti NP and Yahoo NR on the basis of full-floristics and foliage cover class scores using the Bray-Curtis dissimilarity measure.

- Sites 26 and 45: *Phragmites australis* rushland and *Melaleuca quinquenervia* swamp sclerophyll shrubland, which occupy similar habitats and share several species in common.

Based on the above illustration, it would be possible to amalgamate some of the plant communities delineated by means of air photo interpretation. For example, *Eucalyptus tereticornis* DSF/W, *E. microcorys* DSF and *E. tereticornis-E. microcorys* DSF could all be amalgamated into a single map unit. However, it would be unwise to do so given the limited extent of the data set used for analysis, especially where other workers have recognised a difference between, for example *Juncus kraussii* subsp. *australiensis* rushland and *Sarcocornia quinqueflora* subsp. *quinqueflora-Sporobolus virginicus* chenopod shrubland/tussock grassland (Adam et al. 1988, Beadle 1981), or *Eucalyptus pilularis* WSF and *Lophostemon confertus* WSF (Elsol 1991, Forestry Commission of NSW 1989, McDonald & Whiteman 1979), or forests and woodlands of *Eucalyptus tereticornis* and *E. microcorys* (Forestry Commission of NSW 1989). More utilitarian reasons relating to reserve management are also likely to exist for not amalgamating some of the communities derived from air photo interpretation, for example maintaining the distinction between *Melaleuca quinquenervia* SSF/W and *Eucalyptus robusta-M. quinquenervia* SSF/W for the purpose of linking the movement of koalas with the distribution of *Eucalyptus robusta*, a favoured food tree.

Issues of vegetation classification aside, the hierarchical analysis provides some insight into the ecological relationships of the various plant communities defined by air photo interpretation. Some of these relationships are discussed below.

The group of sites comprising Site 3 through to Site 48 (denoted Group A on Fig. 9) are all associated with the Wallis Lake estuary, either as saltmarsh and mangrove vegetation or as fringing swamp forests, swamp woodlands and swamp shrubland.

The group of sites comprising Site 2 through to Site 44 (denoted Group B) are all associated with the older sand mass areas of Booti Booti NP. These sites remain floristically distinct from the foredune communities of Sites 1, 7 and 8 (denoted Group C).

Banksia spinulosa var. *collina-Allocasuarina littoralis-Hakea teretifolia-Ptilothrix deusta-Themeda australis* graminoid clay heathland (Site 49) appears to be floristically more similar to *Themeda australis* sod grassland (Site 9) than it is to other heathland communities associated with the old sand masses (Group B). These graminoid clay heathland and sod grassland communities are restricted to exposed aspects of headlands where the soils have formed from sedimentary bedrock.

Despite an obvious overlap in floristic composition for the tallest stratum, the dry sclerophyll forest and woodland communities from Site 17 through to Site 47 (denoted Group D) are more alike with each other than they are with the wet sclerophyll forest (and rainforest) communities in Group E. The one exception is *Corymbia maculata-Eucalyptus fergusonii* subsp. *fergusonii-E. acmenoides* DSF (Site 12), which links with the wet sclerophyll forest equivalent (Site 11), and another wet sclerophyll community in which *E. fergusonii* subsp. *fergusonii* dominates in the absence of *Corymbia maculata* (Site 14). This outcome presumably reflects the exclusive fidelity of *E. fergusonii* subsp. *fergusonii* to the communities represented by sites 11, 12 and 14. This species has a very

restricted distribution in the reserves where it is confined to Cape Hawke, and it was not recorded in any other communities.

During the field survey for vegetation map preparation, it became apparent that three of the rainforest communities recognised for the reserves using the suballiance typology of Floyd (1990) share many species in common. These three floristically related suballiances are *Cupaniopsis anacardioides* littoral rainforest (Site 29), *Drypetes deplanchei-Sarcomelicope simplicifolia* subsp. *simplicifolia-Cassine australis* var. *australis-Podocarpus elatus* littoral rainforest (Sites 13 and 25), and *Ficus* spp.-*Streblus brunonianus-Dendrocnide* spp.-*Cassine australis* var. *australis* dry rainforest (Site 27). The present hierarchical analysis, superficial though it is, would suggest that the aforementioned rainforest suballiances are floristically similar, yet collectively distinct from *Livistona australis* subtropical rainforest (Site 30) and *Choricarpia leptopetala* dry rainforest (Sites 20 and 24).

Significant plant species

Forty four (6.7%) of the 654 native vascular plant taxa recorded for Booti Booti NP and Yahoo NR in the present and earlier surveys are considered to be of conservation significance (Table 2). Five of the taxa, *Allocasuarina defungens*, *A. simulans*, *Chamaesyce psammogeton*, *Cynanchum elegans* and *Senna acclinis*, are listed under the *NSW Threatened Species Conservation (TSC) Act 1995*. A sixth taxon, *Eucalyptus fergusonii* subsp. *fergusonii*, is listed on the Rare or Threatened Australian Plants (ROTAP) schedule (after Briggs & Leigh 1996). The remaining 38 taxa either approach or reach their distribution limit in the reserves, or are in some way restricted.

A further five taxa of Booti Booti NP, although widespread on coastal sand masses in northern NSW nonetheless reach their southern distribution limit in the Port Stephens area of the lower North Coast, approximately 60 km to the SSW. These taxa are: *Aotus lanigera* (Bell 1997), which was previously thought to extend northwards from Taree (Harden 1991); *Leptospermum liversidgei* (McNair 1992), previously known as far south as Myall Lakes (Harden 1991); *Sporadanthus interruptus* (Harden 1993); *Leucopogon lanceolatus* var. *gracilis* (Harden 1992); and *Leucopogon leptospermoides* (Harden 1992).

Management issues

Fire

Fire management in Booti Booti NP and Yahoo NR will largely be a matter of fire exclusion in the short term, in view of the extent and severity of fires in the last 5–10 years. For the longer term there is a relative paucity of habitat-specific information about the fire behaviour of individual plant species in the reserves other than general post-fire regeneration responses (e.g. Griffith & Williams 1997). Little is also known about the impact of season of burn, the extent to which post-fire weather patterns influence recruitment, and the significance of fire heterogeneity and micro-site variation. Nonetheless, in the absence of further research it is possible to apply

generalised fire interval classes to the different plant communities of the reserves using guidelines developed by the NSW National Parks and Wildlife Service (refer NSW National Parks and Wildlife Service 1997, 1998a,b). Mitigating factors which relate to the generalised fire interval classes are discussed at length in Griffith et al. (1999). These mitigating factors include post-fire weed encroachment, the proximity of 'fire-tolerant' vegetation to 'fire-sensitive' vegetation, the likely impact of peat fires, the severity of a recent unplanned crown fire, anecdotal evidence for already depleted seed pools in certain obligate seed regenerator species, the fire behaviour of significant plant species, and likely shifts in floristic composition where fire is excluded.

Exotic species

Several particularly aggressive weeds are present in Booti Booti NP and Yahoo NR, and some of these pose a serious threat to the long-term viability of native vegetation. **Chrysanthemoides monilifera* subsp. *rotundata* (Bitou Bush) is present as extensive infestations along foredunes and sea cliffs where it is actively displacing native vegetation. **Lantana camara* (Lantana) is also widespread, particularly in former clearings on the Cape Hawke hill complex and along gullies and moist hillslopes elsewhere. **Anredera cordifolia* (Madeira Vine) is present in dry rainforest on Booti Island and Earps Island in Wallis Lake where it blankets the canopy and ground surface. **Anredera cordifolia* was first reported for Booti Island in 1980 (de Castro Lopo 1980). Another vine, **Ipomoea cairica* (Five-leaf Morning Glory), has the potential to degrade areas of swamp sclerophyll forest and woodland associated with the Wallis Lake estuary. **Ipomoea cairica* forms vine towers on saplings, especially those of *Casuarina glauca*, and this can lead to the death of saplings through competition for sunlight. This may be the case in Yahoo NR where many *Casuarina glauca* stems lie on the ground covered in what appear to be the remains of **Ipomoea cairica*. The shrub **Baccharis halimifolia* (Groundsel Bush) is also considered a threat to the estuarine vegetation of Wallis Lake. Only two plants of this species were observed during the present survey, and both were found in Yahoo NR (and subsequently removed). **Baccharis halimifolia* dominates the understorey of some swamp sclerophyll forests along estuaries on the far North Coast of NSW (e.g. Ballina NR and the Iluka Peninsula), and it has the potential to behave in a similar manner on the lower North Coast. Exotic grasses such as **Pennisetum clandestinum* (Kikuyu) persist in former clearings on headlands close to the sea. Exotic grasses have also invaded severely trampled vegetation, e.g. where 4WD vehicles have damaged *Themeda australis* sod grassland.

Unrestricted access

Unrestricted 4WD vehicle, trail bike and pedestrian access has the potential to further degrade native vegetation, particularly in saltmarsh areas, along foredunes, and in *Themeda australis* sod grassland and graminoid clay heathland on headlands. Rubbish dumping is also a problem along tracks and fire trails where public access is unrestricted.

Table 2. Significant vascular plants of Booti Booti National Park and Yahoo Nature Reserve.

The source of each record is given thus: [1] = recorded during the present survey; [2] = recorded in de Castro Lopo (1980), which includes rainforest data by Clough (1979); [3] = recorded by Floyd (1990, undated); [4] = recorded in Dodkin (1978), [5] = recorded by M. Matthes and A. Bofeldt (in Muggeridge 1999). The general fire response of each taxon (rainforest taxa excluded) is given where known.

ROTAP = Rare or Threatened Australian Plants schedule (after Briggs & Leigh 1996); TSC = NSW Threatened Species Conservation Act (1995).

Species	Significance	Fire Response
Allocasuarina defungens (Casuarinaceae)[1]	Occurs at southern distribution limit in Forster area. Endangered (Schedule 1 of TSC Act; ROTAP 2E).	Resprouts (Griffith & Williams 1997)
Allocasuarina simulans (Casuarinaceae)[1,2]	Endemic to Forster and Nabiac areas in vicinity of Wallis Lake (Harden 1990). Vulnerable (Schedule 2 of TSC Act; ROTAP 2VCa).	Resprouts (Griffith & Williams 1997)
Banksia ericifolia var. *macrantha* (Proteaceae)[1,2]	Restricted to coastal habitats of NSW north from Forster area (Harden 1991).	Adults killed (Griffith & Williams 1997)
Callistemon citrinus (Myrtaceae)[1,2]	Although distribution extends from Victoria to Queensland (Harden 1991), not known to occur on coastal sand masses of NSW to north of Forster area.	Resprouts (Griffith & Williams 1997)
Cassinia aculeata (Asteraceae)[1]	Forster is northern distribution limit (Harden 1992).	Adults killed (Benson & McDougall 1994)
Centratherum punctatum subsp. *australianum* (Asteraceae)[1]	Occurrence in Booti Booti NP represents a southern extension of previously known distribution limit at Wingham, approximately 45 km to NW (Harden 1992).	Not known
Chamaesyce psammogeton (formerly *Chamaesyce sparrmanii*) (Euphorbiaceae)[1]	Uncommon species of sand dunes near the sea, and endemic to Qld, NSW and Lord Howe Island (Harden 1990, Heyligers 1998). Endangered (Schedule 1 of TSC Act).	Not known, but habitat not fire-prone
Cleistanthus cunninghamii (Euphorbiaceae)[1,2,3]	Reaches southern limit of coastal distribution in Booti Booti NP (Floyd 1990).	Rainforest taxon
Coleocarya gracilis (Restionaceae)1	Reaches southern distribution limit in Myall Lakes area, approximately 20 km to SSW (Harden 1993, Myerscough & Carolin 1986).	Resprouts (Griffith & Williams 1997)
Cryptandra ericoides (Rhamnaceae)[1]	Previously only known to occur south from Sydney area (Harden 1990).	Adults killed (S.J.G. pers. observ. 1998)
Cynanchum carnosum (Asclepiadaceae)[1,2,4]	Records for Wallis Lake area represent a southern extension of previously known distribution limit (Harden 1992).	Not known, but possibly resprouts from rootstock
Cynanchum elegans (Asclepiadaceae)[1]	Endangered (Schedule 1 of TSC Act).	Not known, but possibly resprouts from rootstock
Desmodium nemorosum (Fabaceae)[1,2]	Reaches southern distribution limit in Booti Booti NP (refer Harden 1991).	Not known
Durringtonia paludosa (Rubiaceae)[1]	A monotypic species, endemic to coastal lowlands of northern NSW and south-eastern Qld where restricted to swampy habitats (Harden 1992, Henderson & Guymer 1984).	Resprouts (Griffith & Williams 1997)
Eucalyptus fergusonii subsp. *fergusonii* (Myrtaceae)[1,2,3]	A very sporadic distribution, previously thought to extend from Bulahdelah to Morisset on lower North Coast and upper Central Coast of NSW (Harden 1991). Poorly known (ROTAP 3KC-).	Probably resprouts
Galactia species A (Fabaceae)[1]	Apparently uncommon on North Coast of NSW.	Not known
Ixora beckleri (Rubiaceae)[2,3]	Reaches southern distribution limit in Forster area (Harden 1992).	Rainforest taxon

Species	Significance	Fire Response
Jagera pseudorhus var. *pseudorhus* f. *pseudorhus* (Sapindaceae)[1]	Reaches southern distribution limit in Myall Lakes NP, approximately 20 km to SSW (M. Dodkin, NPWS pers. comm.). Previously known as far south as Black Head, approximately 16 km to the NNW (Floyd 1989).	Rainforest taxon
Kennedia prostrata (Fabaceae)[2]	Occurrence in Booti Booti NP represents a range extension northwards from Port Stephens (Harden 1991) and Myall Lakes (McNair 1992, Myerscough & Carolin 1986) areas of lower North Coast of NSW.	Not known
Keraudrenia hillii var. *hillii* (Sterculiaceae)[2]	Occurrence in Booti Booti NP represents a range extension northwards from Port Stephens (Harden 1990) and Myall Lakes (McNair 1992) on lower North Coast of NSW. Considered rare.	Not known
Leptospermum semibaccatum (Myrtaceae)[1]	Harden (1991) has Forster as southern distribution limit.	Resprouts (Griffith & Williams 1997)
Macrozamia communis (Zamiaceae)[1,2,3]	Has a near-coastal distribution in north of range (Hill 1998). Reaches northern limit at Hallidays Point, approximately 16 km to NNW.	Resprouts (French & Westoby 1996)
Marsdenia lloydii (Asclepiadaceae)[2]	Reaches southern distribution limit in Wang Wauk State Forest, approximately 30 km to WSW (S. Griffith in NPWS database, Northern Zone).	Rainforest taxon
Melaleuca armillaris (Myrtaceae)[1,2]	Although range extends into Queensland (Harden 1991), not known from coastal headlands of NSW any further north than Forster area.	Adults killed (Griffith & Williams 1997)
Monococcus echinophorus (Phytolaccaceae)[2,4]	Reaches southern distribution limit in Forster area, and considered uncommon in NSW (Harden 1990).	Rainforest taxon
Morinda acutifolia (Rubiaceae)[4]	Reaches southern distribution limit in Dungog area, approximately 80 km to WSW (A.G. Floyd in NPWS database, Northern Zone). Considered uncommon in NSW (Harden 1992).	Rainforest taxon
Ochrosperma lineare (Myrtaceae)[1,2]	Harden (1991) has Forster as southern distribution limit.	Adults killed (Griffith & Williams 1997)
Opercularia varia (Rubiaceae)[1]	Records for Booti Booti NP represent a range extension from previously known northern limit in vicinity of Karuah (Harden 1992) and Myall Lakes (Myerscough & Carolin 1986) on lower North Coast of NSW.	Adults killed (Griffith & Williams 1997)
Parietaria debilis (Urticaceae)[2]	Apparently uncommon on North Coast of NSW (refer Harden 1990).	Not known, but an annual species
Parsonsia induplicata (Apocynaceae)[1]	Reaches southern distribution limit at Stroud, approximately 55 km WSW of Booti Booti NP (Harden 1992).	Not known, but possibly resprouts from rootstock
Persoonia katerae (Proteaceae)[1]	Endemic to NSW where found on coastal sands between Hastings River on mid North Coast and Myall Lakes on lower North Coast (Harden 1991).	Not known
Pisonia umbellifera (Nyctaginaceae)[1,2,3]	Considered widespread but not common in coastal NSW (Harden 1990).	Rainforest taxon
Planchonella myrsinoides (Sapotaceae)[1,2,3]	Reaches southern distribution limit in Forster area (Harden 1990).	Rainforest taxon
Poa poiformis (Poaceae)[1]	Records for Yahoo NR and also Kattang NR south of Port Macquarie (S.J.G. pers. observ.) represent a range extension northwards from Port Stephens on lower North Coast of NSW (Harden 1993).	Not known, but possibly resprouts

Species	Significance	Fire Response
Pterostylis concinna (Orchidaceae)[2]	Occurrence in Booti Booti NP represents a range extension north from Mudgee area on Central Western Slopes of NSW (Harden 1993).	Resprouts
Pultenaea blakelyi (Fabaceae)[1,2]	Records for Booti Booti NP represent a range extension northwards from Myall Lakes, approximately 20 km to the SSW (Harden 1991).	Adults killed (Benson & McDougall 1996)
Randia benthamiana (Rubiaceae)[2,3]	Reaches southern distribution limit in Forster area (Harden 1992).	Rainforest taxon
Ripogonum discolor (Ripogonaceae)[2,3,4]	Reaches southern distribution limit in Myall Lakes area, approximately 20 km to the SSW (Harden 1993).	Rainforest taxon
Senna acclinis (Fabaceae)[5]	Rare (ROTAP 3RC-). Endangered (Schedule 1 of TSC Act).	Rainforest taxon
Tetratheca ericifolia (Tremandraceae)[2]	Distribution extends south from Nabiac area on NW side of Wallis Lake (Harden 1992).	Not known, but possibly resprouts
Tripladenia cunninghamii (Uvulariaceae)[1,2]	Distribution extends north from Myall Lakes area, approximately 20 km to the SSW (Harden 1993).	Not known, but possibly resprouts from a rhizome
Tylophora paniculata (Asclepiadaceae)[1]	Apart from an apparent outlier in Sydney region (A. Bofeldt in NPWS database, Northern Zone), reaches southern distribution limit at Williams River on lower North Coast of NSW (Harden 1992).	Not known, but possibly resprouts from rootstock
Westringia fruticosa (Lamiaceae)[1,2]	Apart from small remnant populations in vicinity of Wallabi Point, approximately 25 km north of Booti Booti NP (S.J.G. pers. observ.), reaches northern distribution limit in Forster area (Harden 1992).	Resprouts (Griffith & Williams 1997)
Xanthosia tridentata (Apiaceae)[1]	Records for Booti Booti NP, Old Bar near Taree (Greater Taree City Council 1996), and Tomaree NP on lower North Coast (Bell 1997) appear to represent a range disjunction northwards from Mount White on Central Coast of NSW (Harden 1992).	Adults killed (Griffith & Williams 1997)

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Appendix 1. Vascular plants of Booti Booti National Park and Yahoo Nature Reserve.

Taxa are listed alphabetically by family and genus within classes. The nomencalture is consistent with current usage at the Royal Botanic Gardens Sydney, and most authorities are given in Harden (1990–93).

The checklist is a compilation of records from the following sources.

[1] = Recorded during the present survey (plot-based sampling and incidental records along foot traverses), or an earlier investigation by Griffith (1987).

[2] = Recorded in a detailed study of the former Booti Booti State Recreation Area by de Castro Lopo (1980). The work of de Castro Lopo also includes rainforest data by Clough (1979).

[3] = Recorded by Floyd (1990, undated).

[4] = Recorded in Dodkin (1978).

[5] = Record of *Senna acclinis* by M. Matthes and A. Bofeldt (in Muggeridge 1999).

A small number of records from sources other than the present survey have not been included in the checklist because they seem doubtful. Any voucher specimens for these records will need to be located and further examined.

Although the checklist is considered comprehensive, further fieldwork is likely to produce additional records for cryptic taxa such as terrestrial orchids. It is also probable that a closer examination of disturbed sites (e.g. roadsides and rest areas) will yield additional records for exotics. Exotic taxa are prefixed with an asterisk.

Index of codes:

The plant communities are named after dominant indicator species of the tallest (dominant) stratum. Each community (or other map unit) has a unique five-digit numeric code. The fifth digit of each code (highlighted in brackets in the index) is used for mapping purposes to signify the crown cover range of the tallest stratum in each polygon: 1 = mid-dense to dense (e.g. open to closed forest); 2 = very sparse to sparse (e.g. open woodland to woodland); 0 = crown cover variable, or else not determined. The '0' code is only used for 'complex' map units (e.g. Foredune Complex) and 'miscellaneous' map units (e.g. cleared land). Missing codes apply to plant communities or other map units not found in Booti Booti NP or Yahoo NR.

Map Code	Plant community or other map unit
	FOREST AND WOODLAND
	Subtropical rainforest
0003(1)	*Livistona australis*
	Littoral rainforest
0502(1)	*Cupaniopsis anacardioides*
0505(1)	*Drypetes deplanchei-Sarcomelicope simplicifolia* subsp. *simplicifolia-Cassine australis* var. *australis-Podocarpus elatus*
	Dry rainforest
1003(1)	*Ficus* spp.-*Streblus brunonianus-Dendrocnide* spp.-*Cassine australis* var. *australis*
1004(1)	*Choricarpia leptopetala*
	Mangrove forest and woodland
2502(2)	*Avicennia marina* subsp. *australasica*
	Wet sclerophyll forest
3002(1)	*Lophostemon confertus*
3004(1)	*Eucalyptus grandis*
3006(1)	*Eucalyptus pilularis*
3007(1)	*Eucalyptus microcorys*
3011(1)	*Eucalyptus tereticornis*
3012(1)	*Eucalyptus fergusonii* subsp. *fergusonii*
3013(1)	*Corymbia maculata-Eucalyptus fergusonii* subsp. *fergusonii-E. acmenoides*
	Dry sclerophyll forest and woodland
3504(1)	*Eucalyptus pilularis*
3508(1)	*Eucalyptus microcorys*
3512(1) 3512(2)	*Eucalyptus tereticornis*
3513(1)	*Allocasuarina littoralis*

Map Code	Plant community or other map unit
3522(1) 3522(2)	*Angophora costata*
3556(1) 3556(2)	*Eucalyptus pilularis-Angophora costata*
3559(1)	*Corymbia maculata-Eucalyptus fergusonii* subsp. *fergusonii-E. acmenoides*
3560(1)	*Eucalyptus tereticornis-E. microcorys*
3561(1)	*Angophora floribunda*
3562(1)	*Corymbia maculata*
	Swamp sclerophyll forest and woodland
4003(1) 4003(2)	*Melaleuca quinquenervia*
4005(1) 4005(2)	*Casuarina glauca*
4098(1) 4098(2)	*Eucalyptus robusta-Melaleuca quinquenervia*
4099(1) 4099(2)	*Melaleuca quinquenervia-Casuarina glauca*
	MALLEE FOREST AND WOODLAND
	Dry sclerophyll mallee forest and woodland
5002(2)	*Eucalyptus pilularis*
	Swamp sclerophyll mallee forest and woodland
5102(2)	*Eucalyptus robusta*
	SHRUBLAND (SCRUB)
	Rain-shrubland
5203(1)	*Choricarpia leptopetala*
	Dry sclerophyll shrubland
5402(1)	*Banksia aemula*
5404(1)	*Melaleuca armillaris*
5410(1)	*Leptospermum laevigatum*
5411(1)	**Chrysanthemoides monilifera* subsp. *rotundata-Acacia sophorae*
	Swamp sclerophyll shrubland
5506(2)	*Melaleuca quinquenervia*
	HEATHLAND
	Dry heathland
5804(1)	*Banksia aemula-Allocasuarina simulans*
5899(1)	Intermediate dry heathland
	Graminoid clay heathland
5905(1)	*Banksia spinulosa* var. *collina-Allocasuarina littoralis-Hakea teretifolia-Ptilothrix deusta-Themeda australis*
	Wet heathland
6002(1)	*Banksia oblongifolia-Leptospermum liversidgei-Sporadanthus interruptus-Sprengelia sprengelioides-Xanthorrhoea fulva*
	CHENOPOD SHRUBLAND
6102(1)	*Sarcocornia quinqueflora* subsp. *quinqueflora-Sporobolus virginicus*
	TUSSOCK GRASSLAND
6202(1) 6202(2)	*Spinifex sericeus*
	SOD GRASSLAND
6302(1)	*Themeda australis*
	SEDGELAND
6402(1)	*Baumea juncea*
6403(1)	*Leptocarpus tenax-Baloskion pallens-Schoenus brevifolius*
	RUSHLAND
6502(1)	*Juncus kraussii* subsp. *australiensis*
6503(1)	*Phragmites australis*

Map Code	Plant community or other map unit
	VEGETATION COMPLEXES
9010(0)	Foredune Complex
9020(0)	Saltmarsh Complex
9030(0)	Headland Complex
	MISCELLANEOUS MAP UNITS
9102(0)	Beach sand, mobile sand (occasionally sandy tidal flats)
9103(0)	Rock
9104(0)	Open water
9202(0)	Partially cleared
9203(0)	Cleared
9204(0)	Disturbance associated with past mining (includes quarries)
9206(0)	Picnic or camping area
9207(0)	Disturbance associated with roads
9208(0)	Disturbance associated with transmission line
9209(0)	Urban or residential development and associated infrastructure (includes housing, public works etc.)

	Plant community or other map unit in which found
CLASS LYCOPSIA	
Lycopodiaceae	
Lycopodiella cernua[1]	05021
Selaginellaceae	
Selaginella uliginosa[1,2]	58991 60021
CLASS FILICOPSIDA	
Adiantaceae	
Adiantum aethiopicum[1,2]	35041
Adiantum formosum[2]	
Adiantum hispidulum[1,2,4]	00031 10031 30131
Adiantum silvaticum[2,3]	05051
Cheilanthes austrotenuifolia[1,2]	35131
Pellaea falcata[1,2,3,4]	00031 05021 05051 10031 35121 35122 35621
Pellaea paradoxa[1,2,3]	05051 30131 35591
Aspleniaceae	
Asplenium attenuatum[2,3]	05051
Asplenium australasicum[2,3,4]	05051 10031
Asplenium difforme[1]	91030
Blechnaceae	
Blechnum camfieldii[2]	
Blechnum cartilagineum[1,2]	30021 30061 30071 35041
Blechnum indicum[1,2]	30041 40031 40032 40981 40982 51022 64031
Blechnum patersonii[2]	
Doodia aspera[1,2,3,4]	05051 10031 30021 30061 30071 30121 30131
Culcitaceae	
Calochlaena dubia[1,2]	00031 30021 30041 30071 35041 35561 35562
Cyatheaceae	
Cyathea australis[2]	
Cyathea leichhardtiana[2]	
Davalliaceae	
Arthropteris tenella[1,2,3]	05051
Davallia solida var. *pyxidata*[2,3,4]	05051 10031
**Nephrolepis cordifolia*[1]	92070

Dennstaedtiaceae	
Histiopteris incisa[2]	
Hypolepis muelleri[1,2,4]	00031 30071 35081 40051 40052
Pteridium esculentum[1,2,3,4]	00031 30021 30061 30121 35041 35081 35131 35221 35222 35561 35562 35591 35611 35621 40031 40032 40981 40982 51022 54021
Dryopteridaceae	
Arachniodes aristata[2]	
Lastreopsis acuminata[2]	
Lastreopsis decomposita[1,2,3]	05021 05051 30021
Lastreopsis microsora subsp. *microsora*[1,2]	05051
Lindsaeaceae	
Lindsaea linearis[1,2]	59051
Polypodiaceae	
Platycerium bifurcatum[1,2,3]	05021 05051 10031 30061 30121 30131
Pyrrosia confluens var. *confluens*[1,2,4]	05051 10031
Pteridaceae	
Pteris tremula[2,3]	05051
Schizaeaceae	
Schizaea bifida[1]	58041
Thelypteridaceae	
Christella dentata[1,2,4]	00031
CLASS CYCADOPSIDA	
Zamiaceae	
Macrozamia communis[1,2,3]	30121 30131 35221 35222 35561 35562 35591
CLASS CONIFEROPSIDA	
Araucariaceae	
**Araucaria heterophylla*[1]	92060
Cuppressaceae	
Callitris rhomboidea[1]	10041
Podocarpaceae	
Podocarpus elatus[1,2,3]	05021 05051 30121
CLASS MAGNOLIOPSIDA-LILIIDAE	
Amaryllidaceae	
Crinum pedunculatum[1,2,3,4]	00031 05021 05051 10031 40991 40992
Anthericaceae	
Arthropodium minus[1,2]	35591
Sowerbaea juncea[1,2]	60021
Thysanotus juncifolius[1,2]	59051
Tricoryne elatior[1,2]	35601 59051
Araceae	
Alocasia brisbanensis[3]	05051
Gymnostachys anceps[1,2,3,4]	05051 10031 10041 30021 30041 30061 30071 30111 30121 30131 35591 35621 52031
Typhonium brownii[1,3]	00031 05051
Arecaceae	
Livistona australis[1,2,3,4]	00031 05021 05051 10031 30021 30041 30061 30071 30121 30131 35041 35221 35222 35561 35562 40051 40052 40981 40982 54041

Asparagaceae	
**Protasparagus aethiopicus*[1]	05021 35041
**Protasparagus plumosus*[1,2]	05021 10031
Asteliaceae	
Cordyline stricta[2]	
Blandfordiaceae	
Blandfordia grandiflora[1,2]	58991 60021
Centrolepidaceae	
Centrolepis fascicularis[2]	
Centrolepis strigosa subsp. *strigosa*[1]	58991
Colchicaceae	
Burchardia umbellata[1,2]	58991 59051 60021
Wurmbea biglandulosa[1]	59051
Commelinaceae	
Aneilema acuminatum[1,3,4]	00031 05051 30021
Commelina cyanea[1,2,4]	05021 00031 10031 10041 30021 30061 30071 35041 35081 35121 35122 35131 35221 35222 35601 35611 35621 40051 40052 40991 40992
**Tradescantia albiflora*[1]	10031 35621
Cyperaceae	
Abildgaardia ovata[1]	63021
Baumea acuta[1]	58991 60021
Baumea arthrophylla[1]	64031
Baumea articulata[1,2]	40031 40032 55062
Baumea juncea[1,2,4]	40051 40052 40991 40992 51022 55062 59051 64021 65031
Baumea muelleri[1]	60021
Baumea rubiginosa[1,2]	55062 65031
Baumea teretifolia[1,2]	64031
Carex appressa[1,2]	00031 30021
Carex breviculmis[1]	35611
Carex brunnea[2]	
Carex pumila[1]	90100
Caustis pentandra[1]	58041 58991
Caustis recurvata var. *recurvata*[1,2]	50022 54021 58041
**Cyperus brevifolius*[2]	
Cyperus enervis[1]	35591 35601
Cyperus flaccidus[2]	
Cyperus laevis[2]	
Cyperus lucidus[2,4]	00031
Cyperus polystachyos[1,2,4]	40991 40992 63021
Cyperus tetraphyllus[1,2]	30061
Cyperus trinervis[1,2]	00031
Fimbristylis dichotoma[1]	63021
Fimbristylis ferruginea[1,2,4]	40051 40052 40991 40992 55062 61021 64021 65021 65031
Gahnia aspera[1,2,3,4]	05051 10031 10041 30061 30111 30131 35131 52031 54041
Gahnia clarkei[1]	30041 35561 35562 40031 40032 40051 40052 40981 40982 51022 54041
Gahnia melanocarpa[1,2]	00031 05051 10041 30021 30061 30071 30111 30121 30131 35611
Gahnia sieberiana[1,2]	60021
Gymnoschoenus sphaerocephalus[1,2]	60021
Isolepis cernua[2]	

Cyperaceae cont.	
Isolepis inundata[1,2]	40981 40982
Isolepis nodosa[1,2,4]	10031 40051 40052 40991 40992 54111 62021 62022 63021
Lepidosperma concavum[1]	54101
Lepidosperma elatius[1,2]	30131 35041 35591
Lepidosperma laterale[1,2]	00031 30111 30121 30131 35041 35121 35122 35131 35591 35601 54041 59051
Lepidosperma neesii[1]	58991 59051 60021 64031
Ptilothrix deusta[1,2]	58991 59051 60021
Schoenoplectus litoralis[1,2]	55062 65021 90200
Schoenus apogon[1]	59051
Schoenus brevifolius[1,2]	51022 58991 60021 64031
Schoenus ericetorum[1,2]	50022 58041
Schoenus lepidosperma subsp. *pachylepis*[1]	58991 60021
Schoenus melanostachys[1,2]	92080
Scleria mackaviensis[1]	35591
Dioscoreaceae	
Dioscorea transversa[1,2,3,4]	05021 05051 10031 10041 30021 30061 30071 30111 30121 30131 35131 35561 35562 52031
Flagellariaceae	
Flagellaria indica[1,2,3]	05021 05051 10031
Geitonoplesiaceae	
Eustrephus latifolius[1,2,4]	10031 30021 30061 30071 30111 30121 30131 35041 35561 35562 35621
Geitonoplesium cymosum[1,2,3,4]	05021 05051 10031 10041 30021 30041 30061 30071 30111 30121 30131 35121 35122 35601 35611 35621 52031
Haemodoraceae	
Haemodorum corymbosum[2]	
Iridaceae	
**Freesia* hybrid[1]	92060
**Gladiolus gueinzii*[1]	62021 62022
Patersonia glabrata[1,2]	50022 58041
Patersonia sericea[1,2]	58041
Patersonia sp. aff. *fragilis*[1,2,3]	35561 35562 58991 59051 60021
**Romulea rosea* var. *australis*[1]	92060
Juncaceae	
**Juncus cognatus*[2]	
Juncus kraussii subsp. *australiensis*[1,2,4]	25022 40051 40052 40991 40992 55062 61021 65021 65031
Juncus mollis[2]	
Juncus planifolius[2]	
Juncus usitatus[2]	
Juncaginaceae	
Triglochin procerum s. lat.[1]	64031
Triglochin striatum[1]	61021
Lomandraceae	
Lomandra confertifolia subsp. *pallida*[1]	35131
Lomandra glauca[1]	50022 58041 58991 59051
Lomandra longifolia[1,2,3]	30021 30061 30071 30121 30131 35041 35081 35121 35122 35131 35221 35222 35561 35562 35591 35601 35611 35621 51022 54021 54101 54111 59051 62021 62022 63021

Lomandraceae cont.	
Lomandra multiflora subsp. *multiflora*[1]	30071 30131 35041 35081 35591 59051
Lomandra spicata[1]	05021 05051 30041
Orchidaceae	
Acianthus exsertus[2]	
Caladenia catenata[2]	
Calanthe triplicata[1,3]	05051
Cymbidium suave[2]	
Dendrobium aemulum[3]	05051
Dendrobium gracilicaule[3]	05051
Dendrobium speciosum[3]	05051
Dendrobium tetragonum[1,3]	05021 05051
Dipodium variegatum[1]	35561 35562
Erythrorchis cassythoides[1]	90300
Microtis parviflora[1]	92060
Pterostylis concinna[2]	
Pterostylis nutans[1,2]	35041
Sarcochilus falcatus[3]	05051
Philydraceae	
Philydrum lanuginosum[1,2]	64031
Phormiaceae	
Dianella caerulea[1,2,3,4]	00031 30021 30061 30071 30121 30131 35041 35081 35121 35122 35131 35221 35222 35561 35562 35591 35601 35611 35621 40051 40052 40981 40982 51022 54021 54041 54101
Dianella congesta[1]	54111 62021 62022
Dianella longifolia[1]	40991 40992
Dianella longifolia var. *longifolia*[4]	00031
Dianella revoluta[1]	35041 35591 50022
Stypandra glauca[2]	
Thelionema caespitosum[2]	
Poaceae	
**Ammophila arenaria*[1]	54111
**Andropogon virginicus*[1]	35041 51022 64031 92030
Aristida ramosa[1]	35621
Aristida warburgii[1]	59051
**Axonopus affinis*[1,2]	92030
**Axonopus compressus*[2]	
**Briza maxima*[1,2]	92030 92070
**Briza minor*[1,2]	92070
**Bromus cartharticus*[1]	92030
Capillipedium parviflorum[1]	35041
Cenchrus caliculatus[2]	
Chloris divaricata var. *divaricata*[2]	
**Chloris gayana*[1,2]	92030 92070
Cymbopogon refractus[1,2]	35041 35131 35591 63021
Cynodon dactylon[1,2]	35131 92030
Dichelachne micrantha[1]	35041
**Digitaria ciliaris*[1]	92070
Digitaria didactyla[1]	63021
Digitaria parviflora[1,2]	35041 35591 35611
Echinopogon ovatus[2]	
**Ehrharta erecta*[1,2]	10031 40051 40052 54101 54111
**Eleusine indica*[1,2]	92070

Poaceae cont.	
Entolasia marginata[1,2]	00031 05021 30021 30071 30131 35041 35121 35122 35131 35221 35222 35601 35621
Entolasia stricta[1,2]	30071 35121 35122 40981 40982 58991
Eragrostis benthamii[2]	
Eragrostis brownii s. lat.[1,2]	35041 58041 59051
**Eragrostis tenuifolia*[1]	92030 92060
Eragrostis trachycarpa[2]	
Eriochloa procera[1,2,4]	40051 40052 40991 40992 64021
Hemarthria uncinata[1,2,4]	40981 40982 40991 40992 51022 64021
Imperata cylindrica var. *major*[1,2,3,4]	00031 30061 30131 35041 35081 35121 35122 35131 35561 35562 35591 35601 35611 35621 40031 40032 50022 51022
Ischaemum australe[1]	40031 40032
Leersia hexandra[2]	
Microlaena stipoides var. *stipoides*[1,2]	90100
Oplismenus aemulus[1,2,4]	00031 05021 05051 35121 35122 35591 35611 35621 40991 40992
Oplismenus imbecillis[1,2]	00031 05051 10031 30021 30041 30061 30111 30121 30131 35041 35081 35591 35601 35611 54041
**Panicum maximum*[2]	
Panicum pygmaeum[1]	10041
Panicum simile[1,2]	50022 58041
Paspalidium aversum[2]	
Paspalidium distans[1]	35041 35131 40981 40982 51022
**Paspalum dilatatum*[1,2]	63021 92030 92070
Paspalum orbiculare[1]	40981 40982
**Paspalum urvillei*[1]	92030 92070
Paspalum vaginatum[1]	90200
**Pennisetum clandestinum*[1,2]	92030
Phragmites australis[1,2,4]	40051 40052 40991 40992 65031
Poa labillardieri[1,2]	30061 30071 30121 30131 35041 35081 35131 35591 35601 35611 35621
Poa poiformis[1]	40051 40052
**Polypogon monspeliensis*[2]	
Sacciolepis indica[1]	40991 40992
**Setaria gracilis*[1,2]	40991 40992
**Setaria pumila*[1,2,4]	40991 40992
Spinifex sericeus[1,2]	54111 62021 62022
**Sporobolus indicus* var. *capensis*[1,2]	35041 35611 63021 92030
Sporobolus virginicus[1,2,4]	25022 40051 40052 40991 40992 61021 63021 64021 65021 91030
**Stenotaphrum secundatum*[1,2]	63021
Themeda australis[1,2]	35041 35081 35121 35122 35561 35562 35591 35601 35611 35621 50022 58041 59051 63021
Thonandia longifolia[2]	
Zoysia macrantha[1,2]	40991 40992 54111 62021 62022 63021
Restionaceae	
Baloskion pallens[1,2]	51022 60021 64031
Baloskion tetraphyllum subsp. *meiostachyum*[1,2]	40031 40032 40981 40982 51022
Coleocarya gracilis[1]	50022 58041
Eurychorda complanata[1,2]	64031
Hypolaena fastigiata[1,2]	50022 58041 58991 60021
Leptocarpus tenax[1,2]	51022 58991 60021 64031
Lepyrodia muelleri[1]	64031

Restionaceae cont.	
Lepyrodia scariosa[1]	58991 60021
Lepyrodia species A[1]	64031
Sporadanthus interruptus[1,2]	51022 58991 60021
Ripogonaceae	
Ripogonum album[1,2]	05051
Ripogonum discolor[2,3,4]	05051 10031
Ripogonum fawcettianum[1,2,3,4]	05051 10031 30021 30131
Smilacaceae	
Smilax australis[1,2,3,4]	05021 05051 10031 10041 30021 30041 30061 30071 30111 30121 30131 35621 52031
Smilax glyciphylla[1,2,3]	05021 30061 30071 35561 35562 54041
Uvulariaceae	
Tripladenia cunninghamii[1,2]	05021 30021 30121
Xanthorrhoeaceae	
Xanthorrhoea fulva[1,2]	40031 40032 51022 54021 60021
Xanthorrhoea macronema[1,2,3]	30121 30131 35041 35121 35122 35221 35222 35561 35562 35591
Xyridaceae	
Xyris gracilis subsp. *gracilis*[1]	58991
Xyris juncea[2]	
Xyris operculata[1,2]	64031
Zingiberaceae	
Alpinia arundelliana[1]	30021
Alpinia caerulea[1]	05051 30021 30061 30071
Alpinia caerulea s. lat.[2,3]	05051
CLASS MAGNOLIOPSIDA-MAGNOLIIDAE	
Acanthaceae	
Pseuderanthemum variabile[1]	00031 05021 05051 10031 30021 30041 30061 30071 30121 30131 35041 35081 35561 35562 35601 35621
Aizoaceae	
Carpobrotus glaucescens[1,2,4]	54101 54111 62021 62022 63021
Macarthuria neocambrica[1]	58041
Sesuvium portulacastrum[1,2,4]	64021
Tetragonia tetragonoides[1,2,4]	62021 62022
Alangiaceae	
Alangium villosum subsp. *polyosmoides*[1,2,3]	05051 10031
Amaranthaceae	
Alternanthera denticulata[1,2,4]	40051 40052 40991 40992
Deeringia amaranthoides[1,2]	05051
Anacardiaceae	
Euroschinus falcata var. *falcata*[1,2,3,4]	05051 10031 30021 30111 30121
Apiaceae	
Actinotus helianthi[1,2]	50022 54021 58041
Apium prostratum subsp. *prostratum*[1,2]	40051 40052 40991 40992 65031 91030
Centella asiatica[1,2]	35081 35621 63021
**Ciclospermum leptophyllum*[2]	
Daucus glochidiatus[2]	
Hydrocotyle acutiloba[1,2]	35611
**Hydrocotyle bonariensis*[1,2]	54111 62021 62022 90100
Hydrocotyle geraniifolia[1]	30061

Apiaceae cont.	
Hydrocotyle peduncularis[1]	00031 30131 35041 35081 35591
Hydrocotyle verticillata[2]	
Platysace ericoides[1,2]	50022 58041 59051
Platysace lanceolata[1,2]	50022 51022 58041 58991 60021
Trachymene incisa subsp. *incisa*[1,2]	35561 35562 58041
Xanthosia pilosa[1,2]	35561 35562 50022 54021 54101 58041 59051 60021
Xanthosia tridentata[1]	59051
Apocynaceae	
Melodinus australis[2]	
Parsonsia induplicata[1]	30111
Parsonsia straminea[1,2,3,4]	05021 05051 10031 10041 30041 30111 30131 40051 40052 52031 54041
Parsonsia velutina[2,3]	05051
Araliaceae	
Astrotricha longifolia[1,2]	30061
Polyscias elegans[1,2,3,4]	00031 05021 05051 10031 30111 35221 35222 35591
Polyscias sambucifolia[1,2]	35041 35561 35562
Asclepiadaceae	
Cynanchum carnosum[1,2,4]	40051 40052 40991 40992 65021
Cynanchum elegans[1]	30111
**Gomphocarpus fruticosus*[1,2]	35121 35122 35591 35611 35621 40991 40992
Marsdenia flavescens[2,4]	10031
Marsdenia rostrata[1,2]	10031 35041 35221 35222 35561 35562
Marsdenia lloydii[2]	
Tylophora paniculata[1]	30041 30121 30131 52031
Asteraceae	
**Ageratina adenophora*[1,2,4]	00031 35611 92030
**Ageratina riparia*[1]	92070
**Arctotheca calendula*[1]	92060
**Arctotheca populifolia*[1]	62021 62022
**Aster subulatus*[1]	40991 40992 64021 65031 92030
**Baccharis halimifolia*[1]	40051 40052 65031
**Bidens pilosa*[1]	92030
**Bidens tripartita*[2]	
Brachycome angustifolia var. *heterophylla*[2]	
Cassinia aculeata[1]	54101
Cassinia uncata[1,2]	90100
Centratherum punctatum subsp. *australianum*[1]	35601
**Chrysanthemoides monilifera* subsp. *rotundata*[1,2]	30021 30061 30071 35041 35081 35121 35122 35131 35561 35562 35601 35611 35621 40051 40052 40991 40992 54041 54101 54111 59051 62021 62022 63021
**Cirsium vulgare*[1,2]	40051 40052 92070
**Conyza albida*[1]	40051 40052 40991 40992 92030
**Conyza bilbaoana*[1]	54111 62021 62022
**Conyza bonariensis*[2]	
**Conyza canadensis* var. *canadensis*[2,4]	40991 40992
**Conyza parva*[1]	40031 40032
**Cotula coronopifolia*[1,2]	40051 40052
Craspedia variabilis[1,2]	59051
**Delairea odorata*[1,2]	05021 40051 40052
Eclipta platyglossa[1,2]	40991 40992

Asteraceae cont.	
Enydra fluctuans[2]	
Epaltes australis[2]	
**Erechtites valerianifolia*[2]	
**Gazania rigens*[1]	92070
Gnaphalium sphaericum[1]	35591
Helichrysum scorpioides[1,2]	59051
**Hypochaeris glabra*[1,2]	92060
**Hypochaeris radicata*[1,2]	40991 40992 63021 92030
**Lactuca serriola*[2]	
Lagenifera gracilis[1]	35041 59051
Leptinella longipes[2,4]	90200
Melanthera biflora[1,2]	9130
Olearia nernstii[1,2,3]	30061 35131 35561 35562
Ozothamnus diosmifolius[1,2]	35121 35122 92030
Pseudognaphalium luteoalbum[1,2]	40991 40992
Senecio hispidulus var. *dissectus*[2]	
Senecio hispidulus var. *hispidulus*[1,2]	35121 35122 35621 40991 40992
Senecio lautus subsp. *maritimus*[1]	62021 62022 63021 91030
Senecio linearifolius[1]	05051
**Senecio madagascariensis*[1,2]	40991 40992 92030 54101
Senecio vagus[1]	30021
**Senecio vulgaris*[2]	
Sigesbeckia orientalis subsp. *orientalis*[1,2]	35121 35122 35591 35621
**Soliva anthemifolia*[2]	
**Sonchus asper* subsp. *glaucescens*[1]	40051 40052 40991 40992
**Sonchus oleraceus*[1,2]	10031 63021
**Tagetes minuta*[1]	92070
Vernonia cinerea var. *cinerea*[1,2]	35041 35081 35621 65031
**Xanthium italicum*[1]	92070
Avicenniaceae	
Avicennia marina subsp. *australasica*[1,2,4]	25022
Basellaceae	
**Anredera cordifolia*[1,2]	10031
Baueraceae	
Bauera capitata[1,2]	60021
Bignoniaceae	
Pandorea pandorana[1,2,3]	05021 05051 10031 10041 30041 30111 30121 30131 35221 35222 50022 54101
Brassicaceae	
**Cakile edentula*[2]	
**Cakile maritima*[1]	62021 62022
Buddlejaceae	
**Buddleja madagascariensis*[1]	40051 40052
Campanulaceae	
Wahlenbergia communis[2]	
Wahlenbergia stricta[1]	35041
Capparaceae	
Capparis arborea[1,2,3,4]	05021 05051 10031 10041 30111
Caprifoliaceae	
**Lonicera japonica*[1]	35621

Caryophyllaceae	
Petrorhagia velutina[1]	92070
Spergularia marina[1]	40051 40052
Stellaria flaccida[2]	
Casuarinaceae	
Allocasuarina defungens[1]	58991
Allocasuarina littoralis[1,2]	35081 35131 35591 59051
Allocasuarina simulans[1,2]	58041
Allocasuarina torulosa[1,2,3]	30131 35041 35121 35122 35591 35601
Casuarina equisetifolia subsp. *incana*[1,2]	90100
Casuarina glauca[1,2,4]	00031 10031 30111 35121 35122 40031 40032 40051 40052 40991 40992 54041 55062 61021 63021 64021 65021 65031
Celastraceae	
Cassine australis var. *australis*[1,2,3,4]	05021 05051 10031 10041 30111 30121 30131 52031
Celastrus australis[1,2,4]	10031
Celastrus subspicata[1,2]	30071 30111 35041
Chenopodiaceae	
Atriplex australasica[2,4]	40991 40992
Atriplex prostrata[1]	40051 40052
Chenopodium glaucum[1,2]	40051 40052
Enchylaena tomentosa[1]	91030
Einadia hastata[1,2]	54111
Einadia nutans[2]	
Einadia nutans subsp. *linifolia*[1]	91030
Rhagodia candolleana subsp. *candolleana*[2]	10031
Sarcocornia quinqueflora subsp. *quinqueflora*[1,2,4]	25022 61021 64021 65021
Suaeda australis[1,2,4]	40051 40052
Chloanthaceae	
Chloanthes stoechadis[1,2]	50022 54021 58041
Clusiaceae	
Hypericum gramineum[1]	35041 59051
Convolvulaceae	
Calystegia marginata[1]	00031
Calystegia soldanella[1]	62021 62022
Dichondra repens[1,2]	30071 30111 30121 35081 35121 35122 35131 35591 35601 35621 63021
Ipomoea cairica[1,2,4]	10031 40051 40052 40991 40992 54111 65021
Ipomoea pes-caprae subsp. *brasiliensis*[1]	62021 62022
Polymeria calycina[1,2]	35041 63021
Crassulaceae	
Crassula sieberiana[1]	91030
Cunoniaceae	
Aphanopetalum resinosum[1,2,3,4]	05051 10031
Schizomeria ovata[1,2]	30021
Dilleniaceae	
Adrastaea salicifolia[1,2]	60021
Hibbertia aspera[1,2]	35041 35081 35221 35222 35561 35562
Hibbertia dentata[1,2]	30021 30061 30071 30121 30131 35221 35222 35561 35562 35601 35611 40031 40032 40981 40982 59051
Hibbertia diffusa[1,2]	54021
Hibbertia empetrifolia[1]	59051

Dilleniaceae cont.	
Hibbertia fasciculata[1,2]	54021 58041 58991 60021
Hibbertia linearis[1,2]	50022 54021 58041
Hibbertia obtusifolia[1,2,3]	35561 35562 54101
Hibbertia riparia s. lat.[1,2]	58991
Hibbertia rufa s. lat.[1]	54021
Hibbertia scandens[1,2,4]	00031 10041 35041 35081 35131 35221 35222 35561 35562 35591 35611 35621 54101 63021
Droseraceae	
Drosera auriculata[1,2]	60021
Drosera peltata[1]	58991 59051 60021
Drosera pygmaea[1]	58991
Drosera spatulata[1,2]	64031
Ebenaceae	
Diospyros australis[1,2,3,4]	05021 05051 10031 10041 30041 30111 30121 30131 35591 52031
Diospyros pentamera[1,2,3,4]	05021 05051 10031 30071 30111 30121 30131 52031
Elaeocarpaceae	
Elaeocarpus obovatus[1,2,3]	00031 05021 05051 10031 30061
Elaeocarpus reticulatus[1,2]	05021
Epacridaceae	
Astroloma pinifolium[1,2]	54101
Brachyloma daphnoides[1]	50022 58041
Epacris microphylla var. *microphylla*[2]	
Epacris obtusifolia[1,2]	60021
Epacris pulchella[1,2]	58991 59051
Leucopogon ericoides[1,2]	50022 54021
Leucopogon juniperinus[1,2]	35041
Leucopogon lanceolatus var. *gracilis*[1,2]	40981 40982
Leucopogon lanceolatus var. *lanceolatus*[2]	
Leucopogon leptospermoides[1]	54021 58991
Leucopogon parviflorus[1,2]	40991 40992 62021 62022
Leucopogon virgatus[1,2]	58041 58991
Monotoca elliptica[1,2]	30131 35561 35562 54101
Monotoca scoparia[1,2]	50022 54021 58041 58991 59051
Sprengelia incarnata[1,2]	60021
Sprengelia sprengelioides[1]	60021
Styphelia viridis[2]	
Trochocarpa laurina[1,2]	05021 30021 30061 30071 30121 30131 35081
Woollsia pungens[1,2]	54021
Escalloniaceae	
Abrophyllum ornans[2]	
Euphorbiaceae	
Actephila lindleyi[1,2,3]	05051
Alchornea ilicifolia[1,2,3]	05021 05051 10031
Amperea xiphoclada[1,2]	50022 54021 58041
Baloghia inophylla[1,2,3]	05021 05051 30041
Breynia oblongifolia[1,2,3,4]	00031 05021 10041 30021 30041 30061 30071 30111 30121 30131 35041 35131 35221 35222 35561 35562 35591 35611 52031 54101
Chamaesyce psammogeton[1]	62021 62022
Claoxylon australe[1,2,3,4]	05051 10031 30021 30041 30071
Cleistanthus cunninghamii[1,2,3]	05051

Euphorbiaceae cont.	
Croton insularis[1,2,3]	05051 90300
Croton verreauxii[1,2]	30071
Drypetes deplanchei[1,2,3,4]	05021 05051 10031 10041 30021 30041 30071 30111 52031
Glochidion ferdinandi var. *ferdinandi*[1,2,3,4]	00031 05021 05051 10031 10041 30041 35041 35561 35562
Mallotus philippensis[1,2,3,4]	05051 10031 30021 30071 30111
Omalanthus nutans[1,2]	40051 40052
Phyllanthus gunnii[1,2]	30071 30131
Poranthera corymbosa[1]	90100
Poranthera microphylla[1,2]	35041
Pseudanthus orientalis[1,2]	58991
Ricinocarpus pinifolius[1,2]	50022 58041 58991
Eupomatiaceae	
Eupomatia laurina[1,2]	05051 30021 30061
Fabaceae-Caesalpinioideae	
Senna acclinis[5]	
**Senna* X *floribunda*[1,2,3]	05021 92030
**Senna pendula* var. *glabrata*[1,2,3]	00031 05051 35081 35131 40051 40052
Fabaceae-Faboideae	
Aotus ericoides[1,2]	54021 58991
Aotus lanigera[2]	
Austrosteenisia blackii var. *blackii*[1]	10031
Bossiaea ensata[1,2]	50022 58041
Bossiaea heterophylla[1,2]	35561 35562 50022 54021 54101 58041
Bossiaea prostrata[1,2]	59051
Canavalia rosea[1,2]	63021 91030
Chorizema parviflorum[2]	
**Crotalaria semperflorens*[1]	92070
Daviesia ulicifolia[1]	35041 35561 35562
Desmodium brachypodum[1,2]	30131 35081 35121 35122 35591 35601 35621 40031 40032
Desmodium nemorosum[1,2]	35221 35222
Desmodium rhytidophyllum[1,2]	35041 35081 35131 35561 35562 35591 35601 35621
Desmodium varians[1,2]	30061 30071 30121 30131 35041 35081 35121 35122 35561 35562 35591 35601 35611 35621
Dillwynia floribunda var. *floribunda*[1,2]	58991 60021
Dillwynia glaberrima[1,2]	58041
Dillwynia retorta[1,2]	35561 35562 50022 54021 58041
**Erythrina* X *sykesii*[1,2]	92060
Galactia species A[1]	63021
Glycine clandestina s. lat.[1,2]	30061 35621
Glycine microphylla[1]	30131 35041 35081 35121 35122 35131 35561 35562 35591
Glycine tabacina s. lat.[1,2]	35121 35122 35601
Gompholobium glabratum[1]	58041
Gompholobium latifolium[1,2]	35221 35222 35561 35562
Gompholobium pinnatum[1]	60021
Gompholobium virgatum var. *virgatum*[1,2]	50022 58041
Hardenbergia violacea[1,2]	30131 35041 35081 35131 35561 35562 35591 35601 35611 35621 50022 58041
Indigofera australis[1,2]	35591
Jacksonia scoparia[1]	35041
Kennedia prostrata[2]	

Fabaceae-Faboideae cont.	
Kennedia rubicunda[1,2,4]	00031 30041 30071 35041 35121 35122 35561 35562 35621 40981 40982 51022
Mirbelia rubiifolia[2]	
Oxylobium ilicifolium[1,2]	35041 35591
Phyllota phylicoides[1,2]	50022 54021 58041
Platylobium formosum[1,2,3]	35041 35561 35562
Pultenaea blakelyi[1,2]	30061 40981 40982
Pultenaea retusa[1,2]	35041 59051
Pultenaea villosa[1,2]	35041
Sphaerolobium vimineum[1]	59051
**Trifolium repens*[1,2]	92070
**Vicia sativa*[1]	92070
Viminaria juncea[1,2]	40991 40992 64031
Fabaceae-Mimosoideae	
Acacia baueri subsp. *baueri*[1]	58991
Acacia binervata[1,2]	30041 30061 35041
Acacia brownii[1]	59051
Acacia elongata[1,2]	40981 40982
Acacia falcata[1,2]	35041
Acacia floribunda[3]	35591
Acacia irrorata subsp. *irrorata*[1,2]	10041 35561 35562 92030
Acacia longifolia[1,2,3,4]	00031 10041 35041 35561 35562 35621 40051 40052 40981 40982 40991 40992 54021
Acacia maidenii[1,2,3,4]	00031 05021 05051 10031 10041 30021 30061 30071 30111 30121 30131 35041 35081 35121 35122 35131 35221 35222 35591 35601 35611 35621 52031 92030
Acacia melanoxylon[1,2]	10041
Acacia myrtifolia[1,2]	35041 59051
Acacia quadrilateralis[1]	58041
**Acacia saligna*[1]	54111
Acacia sophorae[1,2,4]	00031 54101 54111 59051 60021 62021 62022 63021
Acacia stricta[1,2]	35041 35591
Acacia suaveolens[1,2]	35561 35562 50022 54021 58041
Acacia terminalis[1,2]	35561 35562
Acacia ulicifolia[1,2]	35041 35081 35561 35562 50022 54021 58041
Pararchidendron pruinosum var. *pruinosum*[1,2,3,4]	05051 10031 35591
Flacourtiaceae	
Scolopia braunii[1,2,3,4]	05021 05051 10031 30111
Fumariaceae	
**Fumaria capreolata* subsp. *capreolata*[2]	
Gentianaceae	
Centaurium spicatum[1]	40991 40992 64021
**Centaurium tenuiflorum*[2]	
Geraniaceae	
Geranium homeanum[1]	00031 30061 30071 35041 35081 35611
Geranium solanderi var. *solanderi*[1,2]	35591 35621
Goodeniaceae	
Dampiera stricta[1,2]	50022 51022 58041 58991 59051
Goodenia heterophylla subsp. *eglandulosa*[1,2]	35041
Goodenia ovata[1,2]	40051 40052
Goodenia paniculata[1,2]	59051 63021 64021
Goodenia stelligera[1,2]	60021 64031
Scaevola calendulacea[1,2]	54111 62021 62022 90100

Gyrostemonaceae	
Codonocarpus attenuatus[2]	
Haloragaceae	
Gonocarpus micranthus[1,2]	58991
Gonocarpus tetragynus[1,3]	35041 35131 35561 35562 35601 59051
Gonocarpus teucrioides[1,2]	35561 35562 50022 51022 54101 58041
Lamiaceae	
Mentha diemenica[1]	35561 35562 35601
Mentha satureioides[2]	
Plectranthus parviflorus[1,2,4]	10031 35081 35121 35122 35591 35621
Westringia fruticosa[1,2]	54041 59051 63021 91030
Lauraceae	
Beilschmiedia elliptica[1,2,3]	05051
Cassytha filiformis[1,2]	58041 63021
Cassytha glabella forma *glabella*[1,2]	40991 40992 54021 58991 59051 60021
Cassytha pubescens[1,2]	54101
Cinnamomum oliveri[2]	
Cryptocarya glaucescens[1]	05021 30041
Cryptocarya microneura[1]	30021 30061 30071 30131 35561 35562
Cryptocarya obovata[1,2,3]	05051
Cryptocarya rigida[1,2]	05021 05051 30021 30061 30071 30121 35561 35562
Endiandra discolor[1,2]	05051 10041 30111
Endiandra sieberi[1,2,3]	05021 35561 35562
Litsea reticulata[1,2,3,4]	00031 05021 10031 35591
Neolitsea dealbata[1,2,3]	05051
Lentibulariaceae	
Utricularia dichotoma[1]	35561
Lobeliaceae	
Lobelia alata[1,2]	40991 40992 63021 64021 91030
Pratia purpurascens[1,2]	30061 30071 30121 30131 35041 35081 35121 35122 35131 35591 35601 35611 35621 54041
Loganiaceae	
Logania albiflora[1,2]	35041 54041 63021
Mitrasacme paludosa[2]	
Mitrasacme polymorpha[1,2]	58041 60021
Loranthaceae	
Amyema congener subsp. *congener*[1,2]	30111
Amyema congener subsp. *rotundifolia*[2]	
Dendrophthoe vitellina[1]	35561 35562
Muellerina eucalyptoides[1]	30121 35591
Malvaceae	
Hibiscus heterophyllus subsp. *heterophyllus*[2,3]	05051
Hibiscus trionum[2]	
**Modiola caroliniana*[1]	92060
**Sida rhombifolia*[1,2,4]	35611 40991 40992 92030 92060
Meliaceae	
Dysoxylum fraserianum[1,2,3]	05021 05051 10031
Melia azedarach[2]	
Synoum glandulosum[1,2]	00031 05051 10031 30021 30041 30061 30071 30111 30121 35561 35562 40051 40052 54041

Menispermaceae	
Legnephora moorei[1,2]	10041
Sarcopetalum harveyanum[1,2,3]	05021 10031 30061 35041 54111
Stephania japonica var. *discolor*[1,2,3,4]	00031 05021 05051 10041 30021 30061 30071 35041 35121 35122 35221 35222 35561 35562 35621 54041
Menyanthaceae	
Villarsia exaltata[1,2]	64031
Monimiaceae	
Daphnandra micrantha[1,3]	05051
Wilkiea huegeliana[1,2,3,4]	05021 05051 10031 30021 30041 35041 40051 40052 52031 54041
Moraceae	
Ficus coronata[1,2,3]	00031 05051 35041
Ficus fraseri[1,2,3,4]	00031 05021 10031 30111
Ficus obliqua[2,3]	05051
Ficus rubiginosa[1,2,3,4]	05051 10031 10041
Ficus superba var. *henneana*[1,2,3]	05051 10031 52031
Ficus watkinsiana[1,2,3]	05021 05051 10031 30041
Maclura cochinchinensis[1,2,3,4]	00031 05021 10031 92030
Malaisia scandens subsp. *scandens*[1,2,3,4]	05021 05051 10031
Streblus brunonianus[1,2,3,4]	05051 10031 30111 30121
Myoporaceae	
Myoporum acuminatum s. str.[1,2,4]	00031 10031 40051 40052 40991 40992
Myoporum boninense subsp. *australe*[1,2]	63021
Myrsinaceae	
Aegiceras corniculatum[1,2]	25022 40051 40052
Embelia australiana[1,2,3,4]	05021 05051 10031 10041 30021 30041 30071 30111 30121
Rapanea howittiana[1]	05021
Rapanea variabilis[1,2,3,4]	05021 05051 10031 10041 30021 30061 30111 30121 30131 35041 52031
Myrtaceae	
Acmena smithii[1,2,3,4]	00031 05021 05051 10031 30021 30131 54041
Angophora costata[1,2,3]	35041 35221 35222 35561 35562 50022 59051
Angophora floribunda[1,2]	35081 35131 35601 35611
Austromyrtus acmenoides[2,3]	05051
Austromyrtus bidwillii[1,2,3,4]	05021 05051 10031
Backhousia myrtifolia[1,2]	05051
Baeckea diosmifolia[1]	58991
Baeckea imbricata[1,2]	58991
Callistemon citrinus[1,2]	60021
Callistemon pachyphyllus[1,2]	51022 60021 64031
Callistemon salignus[1,2,4]	00031 40991 40992 30111 30121 35561 35562
Calytrix tetragona[1,2]	58041
Choricarpia leptopetala[1]	10041 30111 52031
Corymbia intermedia[1]	30041 35041 35601 35621
Corymbia maculata[1,2,3]	30131 35041 35591 35621
Darwinia leptantha[1,2]	58991 60021
Eucalyptus acmenoides[1,2,3]	30121 30131 35591
Eucalyptus carnea[1]	35041 35081
Eucalyptus fergusonii subsp. *fergusonii*[1,2,3]	30121 30131 35591
Eucalyptus grandis[1,2]	30041 30061 35601
Eucalyptus microcorys[1,2]	30021 30041 30061 30071 35041 35081 35121 35122 35601 35611

Myrtaceae cont.	
Eucalyptus pilularis[1,2,3]	30041 30061 35041 35081 35121 35122 35221 35222 35561 35562 50022
Eucalyptus propinqua[1,2]	30061 35041 35121 35122
Eucalyptus resinifera subsp. *hemilampra*[1]	35041 35081
Eucalyptus robusta[1,2]	00031 40031 40032 40981 40982 51022 54021 64031
Eucalyptus tereticornis[1,2]	30111 35041 35081 35121 35122 35131 35601
Leptospermum juniperinum[1,2]	58991 59051 60021 64031
Leptospermum laevigatum[1,2]	54101 58041
Leptospermum liversidgei[1,2]	58991 60021
Leptospermum polygalifolium[1,2]	40031 40032 40981 40982 51022 54021 58991 59051
Leptospermum semibaccatum[1]	58991
Leptospermum trinervium[1,2]	40981 40982 50022 54021 58041 58991
Lophostemon confertus[1,2]	00031 10041 30021 30041 30061 30071 35041
Melaleuca armillaris[1,2]	54041
Melaleuca ericifolia[1,2]	40031 40032 40991 40992
Melaleuca linariifolia[1,2]	40981 40982
Melaleuca nodosa[1,2]	51022 54021 58991 60021
Melaleuca quinquenervia[1,2,4]	00031 30041 40031 40032 40051 40052 40981 40982 40991 40992 51022 54041 55062 59051 60021 64021 64031
Melaleuca sieberi[1,2]	51022 60021
Melaleuca thymifolia[1,2]	51022 59051 64031
Ochrosperma lineare[1,2]	54021
Rhodamnia rubescens[1,2,3]	05051 30021 30061 30071
Rhodomyrtus psidioides[1,2,3,4]	00031 05021
Syncarpia glomulifera[1,2]	35041
Syzygium australe[2,3]	05051
Syzygium francisii[2,3]	05051
Syzygium oleosum[1,2,3]	05021 05051 40051 40052
Tristaniopsis laurina[2,3]	05051
Nyctaginaceae	
Pisonia umbellifera[1,2,3]	05051
Olacaceae	
Olax stricta[1,2]	51022 58041
Oleaceae	
Jasminum volubile[1,2,3,4]	05021 05051 10031 30111 35591 52031
Notelaea longifolia forma *intermedia*[1,2,3,4]	00031 05021 05051 10031 10041 30021 30041 30061 30071 30111 30121 30131 35081 35221 35222 35561 35562 35591 52031
Olea paniculata[1,2,3,4]	00031 05021 05051 10031 30111 30121 35591
Onagraceae	
**Oenothera affinis*[2]	
**Oenothera mollissima*[1]	92070
Oxalidaceae	
Oxalis chnoodes[1]	30071 30121 35591
Oxalis exilis[1]	35611
Oxalis rubens[1]	62021 62022
Passifloraceae	
**Passiflora edulis*[1,2]	30021 35041
Passiflora herbertiana subsp. *herbertiana*[1,2]	30071 35601 35611
**Passiflora subpeltata*[1,2,3,4]	00031 05051 10031 10041 30021 30061 30071 30121 35081 35121 35122 35131 35611 35621 92030

Peperomiaceae	
Peperomia blanda var. *floribunda*[2,3,4]	05051 10031
Phytolaccaceae	
Monococcus echinophorus[2,4]	10031
**Phytolacca octandra*[2]	
Pittosporaceae	
Billardiera scandens[1,2]	35041 59051
Citriobatus pauciflorus[1,2,3,4]	05021 05051 10031 30021 30041 30061 30071 30111 30121 35591
Hymenosporum flavum[1,2,3]	05051 30021 30041 30061
Pittosporum revolutum[1,2,3,4]	00031 05021 10031 10041 30041 30111 52031
Pittosporum undulatum[1,2,3]	05051 10031 10041 30111 30121 30131 35041 35591 40051 40052 52031
Plantaginaceae	
Plantago debilis[1]	35591 35621 54041 63021
**Plantago major*[2]	
**Plantago lanceolata*[1,2]	92030 92060
Polygalaceae	
Comesperma ericinum[1,2]	58041
Polygonaceae	
Muehlenbeckia gracillima[2]	
Persicaria decipiens[2]	
Rumex brownii[2]	
**Rumex crispus*[2]	
Portulacaceae	
Portulaca oleracea[1,2]	91030
Primulaceae	
**Anagallis arvensis*[1,2]	63021
Samolus repens[1,2]	40991 40992 61021 64021 65021
Proteaceae	
Banksia aemula[1,2]	50022 51022 54021 58041 58991 60021
Banksia ericifolia var. *macrantha*[1,2]	58991 60021
Banksia integrifolia subsp. *integrifolia*[1,2,3]	05021 05051 35561 35562 35611 54101 54111 59051 63021
Banksia oblongifolia[1]	51022 54021 58991 60021
Banksia robur[1,2]	60021
Banksia serrata[1,2]	35221 35222 35561 35562 54101
Banksia spinulosa var. *collina*[1,2]	59051
Conospermum taxifolium[1,2]	58041 58991 60021
Hakea sericea[1,2]	35041
Hakea teretifolia[1,2]	59051 60021 64031
Isopogon anemonifolius[1,2]	50022 58041 58991 59051
Lomatia silaifolia[1,2]	35041
Persoonia katerae[1]	35561 35562
Persoonia lanceolata[1,2]	35561 35562 54101 59051
Persoonia levis[1,2,3]	35561 35562 59051
Persoonia linearis[1,2]	35041 35561 35562 63021
Petrophile pulchella[1,2]	58041
Stenocarpus salignus[1,2,3]	05051
Ranunculaceae	
Clematis aristata[1,2]	05051 30021 35561 35562 35621
Clematis glycinoides[1,2,4]	10031 30111 35591
Ranunculus inundatus[2]	
Ranunculus lappaceus[1,2]	35121 35122

Rhamnaceae	
Alphitonia excelsa[1,2,3,4]	00031 05021 05051 10031 10041 30111 35591 40051 40052
Cryptandra amara[1,2]	59051
Cryptandra ericoides[1]	60021
Emmenosperma alphitonioides[2]	
Pomaderris lanigera[1]	10041 35131
Rosaceae	
**Rubus fruticosus* spp. aggr.[1,4]	00031 92030
Rubus moluccanus var. *trilobus*[1,2]	00031 30021 35041 35121 35122 35611
Rubus nebulosus[2]	
Rubus parvifolius[1,2]	30061 35081 35121 35122 35621
Rubus rosifolius[1]	00031 35611
Rubiaceae	
Canthium coprosmoides[1,2,3]	05021 05051 10041 30071 30111 30121 52031
**Coprosma repens*[1]	92060
Durringtonia paludosa[1]	40031 40032 40981 40982
Galium binifolium[1,2]	30061
Galium ciliare[1]	35591
Galium propinquum[1]	35041
Ixora beckleri[1,2,3]	05051
Morinda acutifolia[4]	10031
Morinda jasminoides[1,2]	05021 05051 10041 30021 30041 30061 30131 52031
Opercularia aspera[1,2]	51022 54101
Opercularia diphylla[1]	35041 35591
Opercularia hispida[2]	
Opercularia varia[1]	50022 51022 58041
Pomax umbellata[1,2]	35561 35562 40031 40032 50022 58041
Psychotria loniceroides[1,2]	30021 30061 30071 30121 30131 52031
Randia benthamiana[2,3]	05051
Rutaceae	
Acronychia oblongifolia[1,2,4]	00031 10031 30021 30041
Acronychia wilcoxiana[1,2,3,4]	05021 05051 10031 30111
Boronia falcifolia[1,2]	58991 60021
Boronia parviflora[1,2]	60021
Boronia pinnata[1,2]	54021 58991
Boronia polygalifolia[1,2]	59051
**Citrus limonia* s. lat.[1]	92030
Correa reflexa var. *reflexa*[1,2,3]	35561 35562 54101 58041
Eriostemon australasius subsp. *australasius*[1,2]	35561 35562 50022 58041
Geijera latifolia[1,2,3]	00031 05051
Phebalium squameum subsp. *squameum*[1,2]	35561 35562
Philotheca salsolifolia[2]	
Sarcomelicope simplicifolia subsp. *simplicifolia*[1,2,3,4]	05051 10031 30111 30131
Zieria laxiflora[1,2]	50022 54021
Zieria smithii[1,2]	30061 30071 30111 35041 35561 35562
Santalaceae	
Exocarpos cupressiformis[1,2,4]	00031 30111 35041 40991 40992
Leptomeria acida[2]	
Sapindaceae	
Alectryon coriaceus[1,2,3,4]	05021 05051 10031
Alectryon subcinereus[1,2,4]	05051 10031 30111 52031
Arytera divaricata[1,2,3,4]	05021 05051 10031

Sapindaceae cont.	
Cupaniopsis anacardioides[1,2,3,4]	00031 05021 05051 10031 30021 30041 30061 30071 30111 30121 30131 35221 35222 40991 40992
Dodonaea triquetra[1,2]	30061 30071 30131 35041 35561 35562 35621 54101
Elattostachys nervosa[1,2,3,4]	05051 10031 30111
Guioa semiglauca[1,2,3]	00031 05021 05051 10031 10041 30041 30061 30071 30111 30121 30131 40051 40052
Jagera pseudorhus var. *pseudorhus* forma *pseudorhus*[1]	05021
Mischocarpus pyriformis subsp. *pyriformis*[1,2,3,4]	05051 10031
Rhysotoechia bifoliolata[1,2,3,4]	05051 10031
Sapotaceae	
Planchonella australis[1,2,3,4]	05021 05051 10031 30021 30111 30121
Planchonella myrsinoides[1,2,3]	05051 10031
Scrophulariaceae	
Bacopa monnieri[1,2]	40991 40992 55062 91030
Euphrasia collina[1,2]	58041
Mimulus repens[2]	
Solanaceae	
Duboisia myoporoides[2,3]	05051
**Physalis peruviana*[2]	
Solanum americanum[2]	
**Solanum linnaeanum*[2]	
**Solanum mauritianum*[1,2,4]	10031 40051 40052 92070
**Solanum nigrum*[1,2,4]	00031 30071
Solanum prinophyllum[1,2]	35121 35122
Solanum pungetium[2]	
Solanum stelligerum[1,2]	30021 30061 35121 35122
Solanum vescum[2]	
Stackhousiaceae	
Stackhousia nuda[2]	
Sterculiaceae	
Commersonia fraseri[1,2,3]	00031 05051 10031 30021 30071
Heritiera actinophylla[1,2,3]	05051
Keraudrenia hillii var. *hillii*[2]	
Stylidiaceae	
Stylidium graminifolium[1,2]	58991 60021
Symplocaceae	
Symplocos thwaitesii[2,3]	05051
Thymelaeaceae	
Pimelea linifolia[1,2]	35041 35561 35562 50022 58041 58991 59051 60021 63021
Wikstroemia indica[1,2]	10031 40051 40052
Tropaeolaceae	
**Tropaeolum majus*[2]	
Tremandraceae	
Tetratheca ericifolia[2]	
Tetratheca thymifolia[1,2]	59051
Ulmaceae	
Celtis paniculata[1,2,3]	05021 05051 10031
Trema aspera[1]	05051 10031 10041 30041 30071 35131 35611

Urticaceae	
Dendrocnide photinophylla[1,2,3,4]	05051 10031 30111
Parietaria debilis[2]	
Verbenaceae	
Clerodendrum tomentosum[1,2,3,4]	05021 10031 10041 30021 30041 30111 30131 52031
Gmelina leichhardtii[1,2]	05051
**Lantana camara*[1,2,3,4]	00031 05021 05051 10031 10041 30041 30061 30071 30111 30121 30131 35121 35122 35131 35221 35222 35561 35562 35591 35601 35611 35621 40051 40052 54041 54101 54111
**Verbena incompta*[1,2]	92030
**Verbena rigida*[1]	92030
Violaceae	
Hybanthus monopetalus[2]	
Viola betonicifolia[1,2]	35041
Viola hederacea[1,2,4]	00031 05021 30121 35081 35221 35222 35601 35611 35621 54041 63021
Viscaceae	
Notothixos cornifolius[1]	05051
Vitaceae	
Cayratia clematidea[1,2,3,4]	00031 05021 05051 10031 10041 30021 30041 30061 30071 30111 35121 35122 35591 35601 35611 35621 40051 40052 54041
Cissus antarctica[1,2,3,4]	00031 05021 05051 10031 10041 30021 30061 30071 30111 30121 40031 40032
Cissus hypoglauca[1,2]	00031 05051 10041 30021 30041 30061 30071
Tetrastigma nitens[1,2,3,4]	05051 10031 30021 30041 30111

Vegetation, soils and management of 'Zara': a sandhill remnant on the Riverine Plain

M.J. Stafford and D.J. Eldridge

Stafford, M.J.[1,3] and Eldridge, D.J[2]. ([1]School of Geography, University of NSW, Australia 2052. [2]Department of Land and Water Conservation, Centre for Natural Resources, c/- School of Geography, University of NSW, Australia 2052. [3]Current address: Australian Water Technologies, 51 Hermitage Rd, West Ryde, NSW, 2114, Australia) 2000. Vegetation, soils and management of 'Zara': a sandhill remnant on the Riverine Plain. Cunninghamia 6(3): 717–746. The 'Zara' exclosure (approximately 35°10'21"S, 144°41'59"E) is on a source-bordering dune on the Riverine Plain north of Deniliquin. The vegetation of this sandhill closely represents the original vegetation that once covered sandhills of the south-west Riverina prior to European occupation. Three vegetation communities comprising six associated Map Units were defined by cluster analysis within the 60 ha exclosure. These were the Callitris Mixed Woodland (Map Units 1, 2, 3, and 6), the Black Box Woodland (Map Unit 5) and the White-top Grassland (Map Unit 4). Seventy-seven taxa were recorded during the survey, and the vegetation was dominated by species from the families Chenopodiaceae and Poaceae. Three shrubs, the exotic weed *Lycium ferocissimum* and the natives *Rhagodia spinescens* and *Enchylaena tomentosa* occurred at more than 75% of sites. The distribution of vegetation communities was strongly associated with attributes of the soil (e.g. soil texture and organic carbon) and plant and litter cover. Vegetation communities occupying remnant sandhills such as the 'Zara' exclosure are some of the most vulnerable communities on the Riverine Plain.

Introduction

Sandhill remnants scattered across the Riverine Plain support restricted and vulnerable plant communities. Their small size, narrow shape and distance from other natural areas render them vulnerable to weed and pest invasion, and continued disturbance by livestock and feral herbivores. Grazing and disturbance and clearing and cultivation for agriculture result in declining recruitment and/or higher mortality of understorey species, and eventually loss of native vegetation cover (Porteners 1993). These sandhill remnants are becoming increasingly valuable for the survival of diminishing plant communities and their associated species (Eardley 1999). Maintenance of these sandhills as 'conservation islands' within a modified landscape depends on our knowledge of the current pressures and threats to these communities.

Only a few remnants, including the 'Zara' exclosure, closely represent the vegetation that once covered the sandhills of the south-west Riverina prior to European occupation.

The 'Zara' source-bordering dune (sandhill), has been recognised for its high biodiversity and conservation value. Brickhill (1985) recommended that the *Callitris*-dominated community at 'Zara' be given high conservation priority, and Porteners (1993) subsequently recommended that regeneration of the site be initiated. The Southern Riverina Naturalists also recognised the conservation value of the 'Zara'

sandhill, and it was eventually fenced off from surrounding grazing land in May 1997. The fencing of the 60 ha sandhill site was supported by station owners F.S. Falkiner and Sons, with funding provided through the Drought Landcare Program of New South Wales National Parks and Wildlife Service. Greening Australia, Conservation Trust Volunteers, Windouran Shire Council and the Deniliquin Rural Lands Protection Board also provided support.

Previous work on vegetation communities on sandy soils on the Riverine Plain has been limited to species inventories, or general discussions of the sandhills in the context of the plain. Little is known about the relationships between plants and soils on these sandhill remnants, and there has been no attempt to quantitatively describe the links between the structure of the communities and the components of the soils and landforms.

Broad regional studies, species lists, management and technical reports, rangeland reviews and literature surveys have been undertaken by the Soil Conservation Service of NSW (Department of Land and Water Conservation), the National Herbarium of NSW, and by individuals such as Moore (1953), Leigh and Mulham (1977) and Cunningham et al. (1981). Porteners (1993) mapped the vegetation of the 'Hay Plain' which covered an area of 4.5 million hectares at a scale of 1: 250 000. Benson et al. (1997) also provide a recent and detailed description of the grasslands of the Riverine Plain.

The objective of this study was to describe the vegetation and soils, and their interrelationships, within the 'Zara' exclosure, and to provide base-line information against which future changes to the vegetation and soils could be compared. The ultimate aim is to provide objective information on which to support the management of the exclosure.

Study area

The study site is located on the Riverine Plain in south-western New South Wales. The Plain is a large expanse of flat alluvial landscape bordered by Narrandera and Balranald, and Ivanhoe and Bendigo. The exclosure is located within 'Zara', a grazing property located approximately 40 km north of Deniliquin, or 10 km east of Wanganella (35°10'21"S, 144°41'59"E) (Fig. 1). The principal land use in the area is sheep grazing on native pastures. The surrounding vegetation is typical of the Riverine Plain with annual grasses such as barley grass (*Hordeum leporinum*) and ryegrass (*Lolium rigidum*) comprising substantial proportions of the pasture. Smaller areas are used for irrigation and dryland cropping.

Isolated sandhills supporting the *Callitris glaucophylla* assemblage occur throughout the region. Those that occur within State Forests, as well as being subject to logging, are often leased out to landholders, and suffer intensive grazing pressure with little or no generation of tree species (Porteners 1993).

While the 'Zara' exclosure is by far the best remaining example of the *Callitris*-dominated community present in the region, it cannot be considered pristine. 'Zara' has been managed as a typical sheep grazing property for the past 150 years. The homestead is located approximately 500 m west of the sandhill, and consequently the

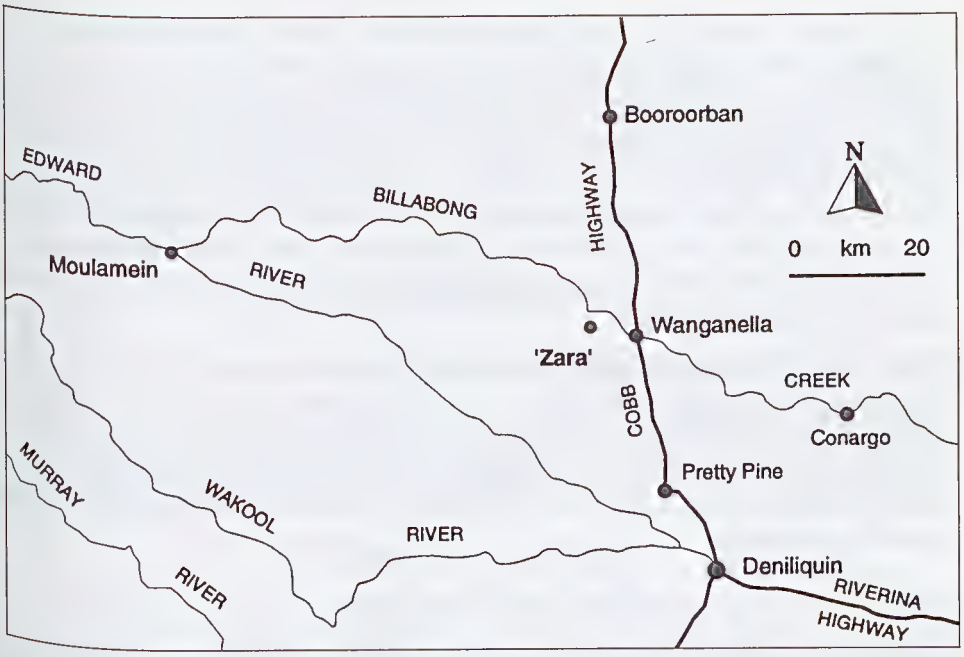

Fig. 1. Location of the 'Zara' exclosure in south-western New South Wales (adapted from Semple 1990).

sandhill would have formed part of the horse paddock surrounding the homestead. Grazing by sheep and cattle would have been intermittent, probably for short periods, as most managers tried to encourage a buffer strip around their homesteads to lessen the impact of dust storms. Ms Officer, the wife of one of the owners in the early part of the century was a keen naturalist, and collected many plant species from the sandhill. Some of her collection is housed at the National Herbarium of NSW. In the 1930s and 1940s the sandhill was apparently used as a golf course, suggesting that shrub cover would have been much less than it is today. Fencing, to exclude rabbits and domestic animals but not kangaroos, was carried out in 1997 using rabbit-proof netting.

The importance of the 'Zara' exclosure cannot be underestimated for several reasons. The exclosure, as well as officially recognising the conservation importance of the sandhill vegetation, encourages future and longitudinal studies of this sandhill. There is already evidence that the rabbit- and sheep-proof fencing has enhanced the regeneration of tree species such as rosewood (*Alectryon oleifolius*) and sugarwood (*Myoporum platycarpum*). Fencing has also enabled the Riverina Field Naturalists to strategically control african boxthorn (*Lycium ferocissium*) within the exclosure and within a buffer strip around the exclosure. Rabbit control has also been initiated with the use of 1080 baiting and warren ripping.

Climate

The climate of the Riverine Plain can be classified as semi-arid, with very hot summers, mild winters and a winter dominant rainfall (Edwards 1979). For the months of January and February, the average daily maximum is approximately 32°C and the average daily minimum for July is about 4°C for the whole of the Riverine Plain (O'Halloran 1995). 'Wanganella', east of 'Zara', has a mean annual rainfall of 337 mm and an average of 53 rain days (Bureau of Meteorology 1998). January and February are the driest months at 'Wanganella', while peak rainfall occurs in May and September (Benson et al. 1997).

Evaporation rates are high, especially in summer and autumn when rainfall is largely ineffective (O'Halloran 1995). Frosts are common between May and September (Cunningham et al. 1981). The most common wind directions are from the south and south-east, although in winter and spring a westerly influence is common. Wind is an important factor in the formation of landforms such as sand dunes which are common on the Riverine Plain.

Landforms and soils

The area surrounding the 'Zara' sandhill consists mostly of alluvial and lacustrine deposits of clay, silt, sand and gravel (Semple 1990). Geomorphically, the sandhill can be described as a source-bordering sandhill which has been derived from the redistribution of coarse stream bed deposits of prior streams and, to a lesser extent, ancestral rivers (Butler et al. 1973). The sandhill is gently sloping, orientated west-east, and was stabilised by vegetation prior to European settlement.

The soils of the 'Zara' sandhill consist of a mixture of siliceous and earthy sands which have a relatively uniform profile with only small changes in colour and texture with depth (Eldridge 1990). The sands are also low in fertility and are highly susceptible to wind erosion once the stabilizing vegetation is removed. Red and brown texture contrast (duplex) soils occur at the margin of the sandhill and the plain. Their surface textures are generally coarse sandy to loamy sands, grading to clayey subsoils often with carbonate at depth. Texture contrast soils are susceptible to windsheeting and scalding (Eldridge 1990).

Vegetation

Much of the Riverine Plain, particularly in the western section, supports chenopod shrubland dominated by *Atriplex vesicaria* and *Maireana aphylla*, and to a lesser extent *Atriplex nummularia* (Porteners 1993). To the east this shrubland has been replaced by a grassland dominated by *Notodanthonia caespitosa* and other perennial and annual grasses. Much of the Riverine Plain has been modified by grazing which has led to a change in vegetation community from *Atriplex vesicaria* to *Sclerolaena* spp. and annual *Atriplex* spp. Grazing pressure has also encouraged the dominance of *Nitraria billardieri* and annual grasses such as *Hordeum leporinum*. On rangelands which are periodically inundated, *Atriplex vesicaria* is often replaced by *Maireana aphylla*.

The Southern Riverina Naturalists compiled a list of 129 species from 44 families from the 'Zara' Exclosure (Mulham, unpublished data). Whilst this study provided a valuable initial assessment of the conservation value of the exclosure, no attempt was made to rate the abundance, importance, or uniqueness of the species within the exclosure or to relate these species to the underlying environmental attributes that determine species distribution.

Field Methods

Establishment of permanent grid points

Sixty permanent grid points were marked out at regular intervals of 30 m by 30 m across the exclosure. The points were identified on a 1: 10 000 black and white aerial photograph before being marked permanently in the field with numbered steel pegs.

Vegetation measurements

At each point a circular plot of 10 m radius was established for the collection of plant and soil data. Cover and abundance of each plant species were assessed during summer (January 1998) at each site using a modified Braun-Blanquet scale where: 1 = < 5% cover and < 5 individuals, 2 = < 5% cover and > 5 individuals, 3 = 5–25% cover, 4 = 25–50% cover, 5 = 50–75% cover, and, 6 = > 75 % cover (Mueller-Dombois and Ellenberg 1974). The botanical names used in this report follow Harden (1990–1993).

Soil surface condition assessment and soil sampling

At each site, attributes of the soil surface were measured in two 0.25 m^2 quadrats placed on opposite sides of the 10 m radius plot. Methods for assessing soil surface condition (Table 1) were adapted from Tongway (1995).

Table 1. Environmental variables used in the Canonical Correspondence analysis.

Variable	Code	Range of values	Description
slope	SLOPE	(1–5)	0% (1) to > 10% (5)
microtopography	MICRO	(1–5)	< 3 mm (1) to > 100 mm (5)
crust coherence	COHER	(1–5)	sand (1) to non-brittle or self mulching (5)
cracking	CRACK	(1–4)	extensively broken (1) to intact (4)
firmness	FIRM	(1–4)	very loose (1) to firm (4)
cryptogams	CRYPT	(1–4)	< 1% (1) to > 50% (4)
erosion amount	SHEET	(1–4)	extensive (1) to insignificant (4)
soil cover	PCOV	(1–5)	< 1% (1) to > 50% (5)
basal cover	BCOV	(1–4)	< 7 mm (1) to > 140 mm (4)
simple litter cover	LCOV	(1–6)	< 10% (1) to 100% (several cm thick) (6)
litter source	SOURCE	(1–2)	transported (1) to local (2)
litter incorporation	LCORP	(1–3)	low (1) to extensive (3)

Slope within the site was classified as 0%, 1–3%, 3–5%, 5–10% or > 10%. **Surface microtopography**, defined as the vertical difference between the highest and lowest point at the site, was recorded. Increases in this vertical difference, increases the soil's potential to retain and store rainfall, leading to potentially higher biological activity. The five classes were; < 3 mm, 3–8 mm, 8–25 mm, 25–100 mm and > 100 mm.

Crust coherence gives a measure of the crust's resistance to disruption, and is assessed as the resistance of the soil surface to an object equivalent to the diameter of a pencil. The 'resistance' indicates the ability of the surface to resist stress immediately upon wetting, or to reform after wetting (Tongway 1995). Crust coherence classes were ranked as: sandy (single grained), easily broken, moderately hard, very hard, non-brittle or self mulching (clay aggregates). Increasing number corresponds to the soils increasing predisposition to hardsetting.

Soil firmness or stability when subject to raindrop impact was estimated in the field. The categories were ranked as firm, moderately firm, loose or very loose. The less firm a soil the more potential there is for erosional loss of fines and greater impermeability on drying (Tongway 1995).

Relative cracking was measured by estimating the percentage of the soil surface covered by cracks. This relates to what degree the surface material is loosely attached and therefore its capacity to disintegrate and erode. It may also be related to the potential for microsites and consequently seed lodgement. Four categories were used: extensively broken, moderately broken, slightly broken and intact.

The cover of cryptogams, grass butts and understorey plants was measured to indicate the degree of cover on the soil at each site and therefore to determine the soil's ability to resist erosion. **Cover of cryptogams** (microphytic crusts; Eldridge & Greene 1996) was classified as: < 1 %, 1–10 %, 10–50 % or > 50 %. As cryptogams are a positive indicator of stability, increasing cover equates with a more stable soil (Tongway 1995).

The **grass basal cover** was estimated in the following classes: 7 mm, 7–70 mm, 70–140 mm or > 140 mm. These values indicate the contribution that the underground biomass (roots) is making to the nutrient pool (cycling). The **plant cover** values indicate the degree to which foliage cover of perennial grasses and any perennial shrubs, less than 0.5 m above the ground, protects the soil surface from rainsplash erosion. Because of the greater potential of gravity drops falling from the foliage of trees and shrubs taller than 0.5 m to erode soil, only foliage of vegetation < 0.5 m was included (Tongway 1995). The cover was estimated as: < 1 %, 1–15 %, 15–30 %, 30–50 % and > 50 %.

The percentage of **soil covered by litter** was recorded, along with an assessment of whether this litter was local or transported, and the degree of incorporation into the soil. The percentage of litter cover was represented by six classes: < 10%, 10–25%, 25–50%, 50–75%, 75–100% or 100% but several centimetres thick. The litter was either transported (material originated elsewhere and can be more easily lost) or local. The incorporation of this litter was assessed to be either low, moderate or extensive.

The **degree of erosion** at a site was classed as extensive, moderate, slight or insignificant. This gives an indication of the severity of active or current loss of soil

material (Tongway 1995). If evidence of erosion existed, then the type (sheeting, scarping, scalding, terracing, hummocking, rills or gullies) was noted, and the eroded material (sand, gravel or clay) was recorded. The types recorded are defined in Tongway (1995).

Four soil samples were collected from a depth of 10 cm from within each circular plot and bulked for an assessment of soil chemical properties.

Organic carbon (OC) was determined using the modified Walkley-Black method (Colwell 1969). Replicates of a 1:5 soil and water solution were used to measure the hydrogen ion concentration (pH) and electrical conductivity (EC) after shaking. Soils were assigned to six texture (TEXT) classes (sands, sandy loam, loams, clay loam, clay) using the bolus method of Northcote (1979).

Data analysis

Vegetation relationships

A species-by-site matrix was constructed to examine groupings of the 60 sites based on cover-abundance of the vascular plants. Of the 77 species recorded, 37 were eliminated from the analysis as they occurred in < 7 (10%) of the sites. The aim of this reduction was to increase the clarity and simplicity of the interrelationships between sites and species, and to reduce the impact of locally 'rare' or infrequent species upon this interpretation.

The reduced data matrix of 60 sites by 40 species (including exotic species) was classified using an hierarchical agglomerative cluster analysis using the Bray-Curtis dissimilarity measure and the Ward's Incremental Sum of Squares (WISS) grouping strategy (Belbin 1990). This analysis produced a grouping of sites that were relatively 'similar' to each other but relatively 'different' to all sites in other groups based on the cover-abundance of species. Unweighted pair group method using arithmetic averages (UPGMA) was also used to cluster the sites in order to determine the robustness of the clusters. An optimal number of groups (Map Units) was determined by examining the point of inflection on a plot of the number of possible groups by dissimilarity level.

Correlations between the number of species and the number of exotics recorded for each Map Unit were determined using Pearson's correlation coefficient (r). Species richness (the average number of species within each Map Unit) was calculated. A measure of diversity, the Shannon-Wiener index, was calculated to account for the varying patterns of species abundance.

Relationships between vegetation and environmental variables

Canonical Correspondence Analysis (CCA) using CANOCO Version 2.1 (ter Braak 1991) was used to examine relationships between the measured environmental variables and the distribution of species within the exclosure. The environmental variables are represented by vectors whose length indicates the relative

importance of each variable in determining the axes. The angle between a vector and an axis is an inverse measure of their correlation. The location of species scores relative to the environmental variables indicates those species or groups of species which have the greatest affinity with the measured environmental variables (ter Braak 1986).

Of a total of 24 environmental variables, nine were omitted from the CCA either to increase the clarity of the relationship between soil variables and species distribution or because the values for some variables did not change across the 60 sites. An environmental data set matrix was constructed using 120 rows (60 sites by 2 quadrats per site) by 15 environmental variables. The environmental variables include the 12 listed in Table 1, as well as soil texture (TEXT), organic carbon (OC) and electrical conductivity (EC). The significance of the environmental variables was tested using a Monte Carlo simulation in the CANOCO package (ter Braak 1991). Accordingly, all insignificant environmental vectors were omitted from the CANOCO biplots. Relationships between the environmental variables and the 60 sites were examined by projecting the 60 site locations, coded for Map Unit, onto the first two axes of the CCA biplot.

Statistical analysis

Data were tested for normality and homogeneity of variance and transformed where necessary ($\log_{10}$, reciprocal, y^3) to meet parametric assumptions. Differences in richness and diversity were tested using one-way analysis of variance (ANOVA) and significant differences determined using Tukey's H.S.D. test. Data which were not normally distributed, or which had unequal variances, were tested using the non-parametric Kruskal-Wallis test (Minitab 1989).

Results

Floristics of the 'Zara' exclosure

Seventy seven taxa (species and subspecies) representing 32 families and 65 genera were recorded in our study (Appendix 1). Together with those species recorded by the Southern Riverina Field Naturalists (Mulham, unpublished), a total of 144 taxa (43 families, 110 genera) have been recorded in the exclosure (Appendix 1). The ROTAP species (*Ptilotus extenuatus*) and a Schedule I species under the Threatened Species Act (*Calotis moorei*) both recorded from the sandhill, were not found during the current survey or by the Riverina Field Naturalists.

As the survey of the 'Zara' exclosure was made at only one point in time, i.e. a hot summer with below average rainfall, a large number of species normally found in the area were not encountered. As a large number of annuals in the Riverina are winter growing (Leigh & Mulham 1977), only summer growing species and the main drought tolerant or drought avoiding plants were recorded. This may explain why only 20 of the 44 known exotics were found during the current survey.

Families known to contain a conspicuous number of exotics such as Poaceae, Brassicaceae and Boraginaceae occurred at more than half of the sites sampled (Table 2). Only 12 species occurred in more than half of the sites (Table 3), and of these three were exotic, and included the declared noxious weed *Lycium ferocissimum*. Examination of Table 3 and Appendix 1 indicates that *Rhagodia spinescens* and *Enchylaena tomentosa* occurred in more than 45 sites and in all Map Units. These shrubs, from the family Chenopodiaceae, could be regarded as characteristic of the 'Zara' exclosure. A high proportion (48%) of species occurred in less than 10% of the sites.

Table 2. The most common families surveyed within the exclosure.

[1]frequency is out of a total of 77 (the total number of species found in the present study), [2]frequency is out of a total of 144 (the total number of species found in the present study and Mulham's unpublished study).

Family	No. of sites occupied	Frequency[1] of species found during the current survey (% out of 77)	Frequency[2] of species found for 'Zara', overall (% out of 144).
Chenopodiaceae	60	15 (19%)	16 (11%)
Poaceae	60	13 (17%)	24 (17%)
Aizoaceae	38	1 (1%)	1 (1%)
Brassicaceae	38	2 (3%)	4 (3%)
Santalaceae	38	3 (4%)	3 (2%)
Boraginaceae	36	3 (4%)	3 (2%)
Sapindaceae	34	2 (3%)	2 (1%)
Fabaceae	33	5 (7%)	10 (7%)
Solanaceae	32	3 (4%)	3 (2%)
Asteraceae	11	5 (7%)	22 (15%)

Table 3. The most common species found during the survey.

Frequency refers to the number of sites, out of 60, where the particular species was found. *indicates an exotic species.

Species Name	Frequency	Family
Rhagodia spinescens	58	Chenopodiaceae
Stipa spp.	50	Poaceae
Enchylaena tomentosa	45	Chenopodiaceae
Bromus arenarius	45	Poaceae
**Mesembryanthemum crystallinum*	38	Aizoaceae
Enteropogon acicularis	36	Poaceae
Notodanthonia caespitosa	35	Poaceae
Stipa elegantissima	33	Poaceae
**Echium plantagineum*	33	Boraginaceae
Exocarpos aphyllus	32	Santalaceae
Dodonaea viscosa subsp. *angustissima*	31	Sapindaceae
**Lycium ferocissimum*	30	Solanaceae

Vegetation groupings based on site classification

The dendrogram (Fig. 2) indicated that six groups (Map Units) provided the most appropriate level of detail for mapping the vegetation in the exclosure. These six Map Units corresponded to three intergrading vegetation communities found on the Riverine Plain (Cunningham et al. 1981, Semple 1990, Porteners 1993), and closely reflect the vegetation patterns observed on the aerial photograph (Fig. 3).

Species found within each of the six Map Units, and the percentage of sites occupied by each species within a Map Unit are shown in Appendix 1. While Map Units 1 to 5 lay within generally well-defined communities, boundaries between these units are gradational. Map Unit 6 represents a transition from one community to another. As Map Units 1, 2, 3 and 6 have similar complements of species compared to Map Units 4 and 5, these units are discussed together. In discussion of Map Units 1, 2, 3 and 5, superscripts indicate the Map Units in which the species occur, and no superscript indicates occurrence in all four Map Units.

Map Units 1, 2, 3 and 6: *Callitris* Mixed Woodland

Map Units 1, 2, 3 and 6 correspond to the *Callitris* Mixed Woodland described by Porteners (1993). See Figs 3 and 4. *Callitris glaucophylla* was abundant in Map Unit 1 but scattered in Map Units 2 and 3. *Alectryon oleifolius* subsp. *canescens*, which was scattered within Map Units 1 and 2, appears to replace *Callitris glaucophylla* as the latter diminishes. The understorey consisted of *Rhagodia spinescens*, *Dodonaea viscosa* subsp. *angustissima*, *Hakea tephrosperma*[12], *Eremophila longifolia*, *Atriplex nummularia*[23] and *Enchylaena tomentosa*. *Lycium ferocissimum* and *Exocarpos aphyllus* were also found in Map Units 1, 2, 3 and 6.

Ground flora comprised short-lived annual and perennial grasses and herbs, many of them exotics (Porteners 1993). These included *Mesembryanthemum crystallinum*[123], *Bromus arenarius*, *Stipa* spp., *Echium plantagineum*, *Stipa elegantissima*, *Notodanthonia caespitosa*[236] and *Sisymbrium erysimoides*[12]. Species found at a low number of sites included *Sisymbrium orientale*, *Schismus barbatus*, *Einadia nutans*, *Hordeum leporinum* and *Jasminum lineare*. *Vulpia myuros* was abundant in Map Units 1, 3 and 6, while *Atriplex nummularia* and *Trifolium arvense* characterized both Map Units 2 and 3. Map Unit 6 was characterized by the absence of *Mesembryanthemum crystallinum* and a very low cover-abundance of *Dodonaea viscosa* subsp. *angustissima*.

Map Units 1 and 2 accounted for the greatest coverage of the exclosure (Fig. 3), and supported the greatest number of either native or exotic species. The number of exotics and the total number of species, for each Map Unit, were significantly positively correlated ($r = 0.91$, $P < 0.02$). Of the four Map Units included in the *Callitris* Mixed Woodland, only Map Units 1 and 2 had unique species. Of the 71 species within the *Callitris* Mixed Woodland, 29 were absent from both Map Units 4 and 5.

Map Unit 4: White-top Grassland

Map Unit 4 corresponded to Porteners (1993) White-top Grassland with the perennial grass *Notodanthonia caespitosa* abundant at all sites (Fig. 5). Associated grasses of high abundance included the perennials *Stipa* spp., *Enteropogon acicularis*, *Elymus scaber* var.

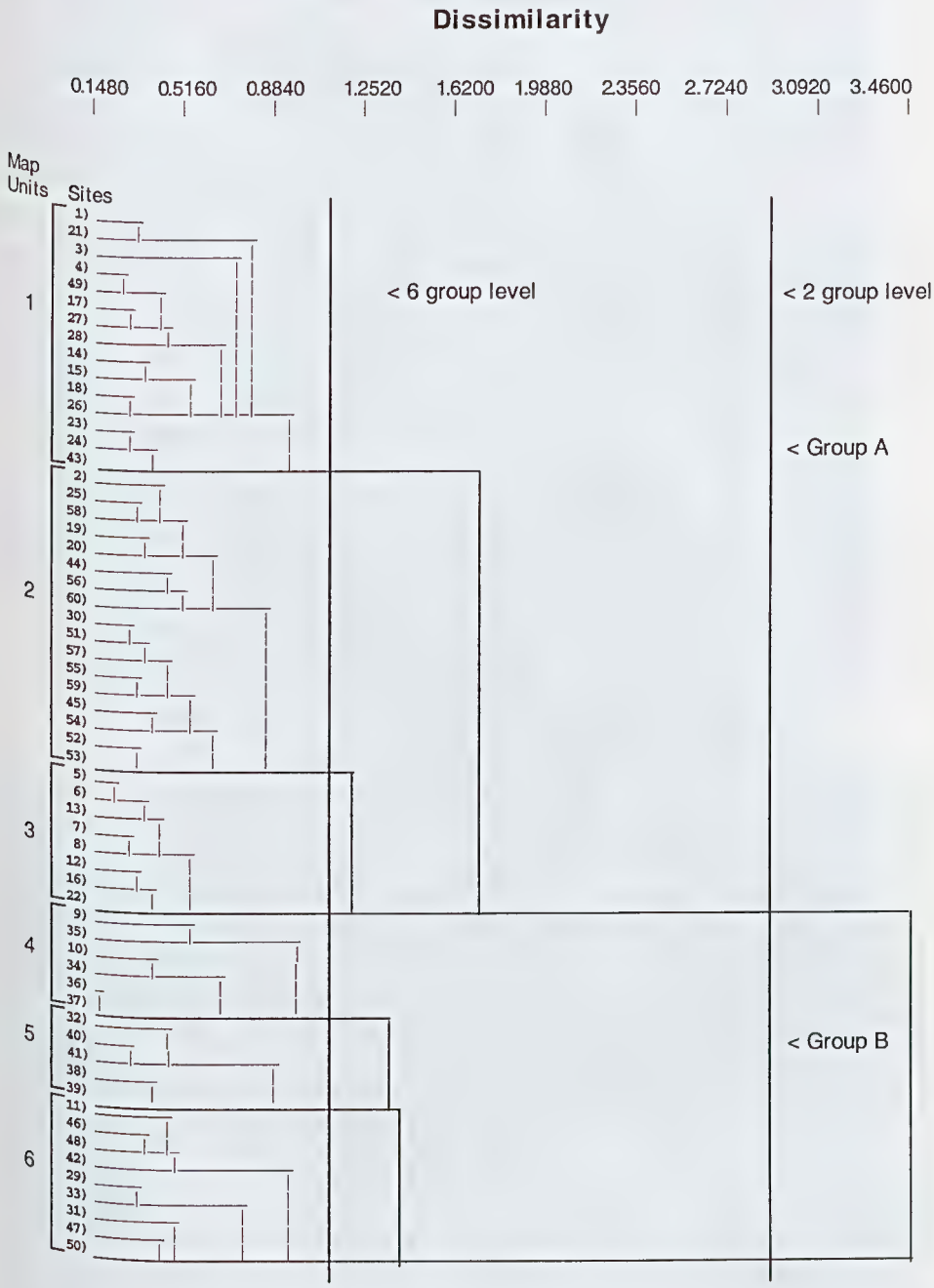

Fig. 2. Dendrogram showing the classification of the 60 sites into the six Map Units based on species abundance and cover.

Fig. 3. Distribution of the six Map Units and three vegetation communities defined by cluster analysis.

scaber and the exotic annual *Hordeum leporinum*. Associated forbs included the annual weed *Echium plantagineum*, and the perennial *Maireana pentagona*. Perennial shrubs *Rhagodia spinescens*, *Atriplex semibaccata* and *Enchylaena tomentosa* were also associated with *Notodanthonia caespitosa* in Map Unit 4.

Apart from the absence of trees and taller shrubs, Map Unit 4 is distinguished from the other units by the absence of *Bromus arenarius*, *Stipa elegantissima*, *Sisymbrium orientale* and *Lycium ferocissimum*. This unit also has the lowest mean number of species per site, the lowest total number of species, and the lowest number of exotics.

Statistically, the lower species diversity of the White-top Grassland (Map Unit 4) was significantly different to the higher diversity of the *Callitris* Mixed Woodland (Map Units 1, 2, 3 and 6; $F_{5,54} = 5.01$, $P < 0.05$). Species richness was also greater for Map Units 1, 2 and 3 of the *Callitris* Mixed Woodland which was significantly different to the lower species richness of the White-top Grassland (Map Unit 4; $F_{5,54} = 7.68$, $P < 0.05$). Although these results give an indication of species richness and diversity across the site, the data are probably influenced by season.

Map Unit 5: Black Box Woodland

Map Unit 5 was characterised by a high cover-abundance of *Eucalyptus largiflorens* (Fig. 6). This unit accounted for the smallest coverage of the exclosure (Fig. 3) and included 29 native and 7 exotic species. The number of species per site ranged from 12 to 17. *Eucalyptus largiflorens* was associated with, in order of abundance, the perennial shrubs *Rhagodia spinescens*, *Enchylaena tomentosa*, *Exocarpos aphyllus*, *Einadia nutans* and

Fig. 4. *Callitris* Mixed Woodland with a *Rhagodia spinescens* and *Atriplex nummularia* understorey.

the noxious weed, *Lycium ferocissimum*. Associated ground flora included the perennial grasses *Notodanthonia caespitosa, Enteropogon acicularis, Stipa elegantissima* and the biennial exotic forb *Sisymbrium orientale*.

Apart from the absence of *Mesembryanthemum crystallinum* and *Dodonaea viscosa* subsp. *angustissima*, Map Unit 5 is distinguished from the other units by the notable absence of *Stipa* spp., *Bromus arenarius* and *Echium plantagineum*. Species endemic to Map Unit 5 were *Eriochlamys behrii, Spergularia rubra* and *Atriplex pseudocampanulata*.

Species-environment relations

Axes I and II of the CCA biplot (Fig. 7) accounted for 35.2% and 20.3% respectively of the variation in species distribution. The length of the vectors shown in Fig. 7 indicates the relative importance of the environmental variables in determining the two axes. Significant and important determinants of axis I were soil texture (proportion of sand in the soil), organic carbon, surface firmness, degree of cracking, crust coherence, cryptogam cover and electrical conductivity. Axis I consequently corresponded to a gradient of increasing clay content from left to right in Fig. 7. Plant cover, microtopography and litter cover were important determinants of axis II, with soil cover increasing from the top of Fig. 7 to the bottom. The angle between a vector and an axis provides an inverse measure of the relationship between the various environmental variables. As such, litter cover and plant cover are shown to be inversely related.

Fig. 5. White-top Grassland characterised by *Notodanthonia caespitosa* associated with *Stipa* spp., *Enteropogon acicularis* and some *Rhagodia spinescens* shrubs

The majority of the 30 species, including those omitted from the plot for cartographic reasons, were clustered close to the centroid (origin). These were generally species common at most sites (e.g. *Rhagodia spinescens* (Rgsp) and *Enchylaena tomentosa* (Ehlt)) or species which showed little affinity with any of the measured environmental variables. Some species however showed strong preferences for certain environmental variables. In the upper left-hand sector of the CCA biplot (Fig. 7) are those species which are correlated with sandy (coarse-textured) soils with moderate levels of litter cover. These include *Callitris glaucophylla* (Klta), *Alectryon oleifolius* subsp. *canescens* (Aleo) and *Dodonaea viscosa* subsp. *angustissima* (Ddat). *Hakea tephrosperma* (Hkts) showed an affinity with increasing levels of litter cover and reduced plant cover, whilst *Mesembryanthemum crystallinum* (Msbc) was associated with soils of reduced clay content, low electrical conductivity and sparse cryptogam cover. The above are the key species that define the *Callitris* Mixed Woodland. Their distribution on the biplot indicates their relative contributions in defining the community.

Two species, *Hordeum leporinum* (Hodl) and *Maireana pentagona* (Mapg; lower right sector) were associated with sites of high clay content and abundant plant cover. *Notodanthonia caespitosa* (Dacp), *Enteropogon acicularis* (Enta) and *Echium plantagineum* (Ekmp) are also associated with predominantly clay textured soil, although to a lesser extent. Those that were also correlated with rough soils (high microtopography), high foliage cover of plants, low levels of organic carbon and a lower clay content (lower left-hand sector), included *Citrullus lanatus* (Ctrl) and *Atriplex nummularia* (Atnm).

Fig. 6. Black Box Woodland dominated by *Eucalyptus largiflorens* with an understorey of *Rhagodia spinescens*.

Eucalyptus largiflorens (Uklf) occurred in the right hand sector of Fig. 7 and is strongly associated with sites of abundant litter cover, loamy soils (high organic carbon levels) and with a sparse foliage cover. *Einadia nutans* (Einn) and *Acacia salicina* (Aksa) also showed a similar association.

Soil surface condition

The soil surface in the exclosure was generally intact, moderately stable and uneroded, with low to moderate microtopography on low (< 3%) slopes (Table 4). Approximately half of the surfaces were non-coherent, and the majority of soils had sandy or sandy loam surface textures. Litter cover in the quadrats was moderate, locally derived i.e. not transported from elsewhere, and poorly broken down and incorporated into the soil surface. Predictably, given soil surface textures, cryptogam cover was sparse. While foliage cover of vascular plants was highly variable across the exclosure, basal cover was generally low. The dominant erosion form at the site was sheet erosion of sandy material.

Table 4. Distribution of the soil surface variables across the 60 sites.

Classes are shown in the first row, and the percentage of each class is given in the second row.

A. Slope (%)	**0**	**1–3**	**3–5**	**5–10**	**> 10**	
	11	86	2	1	0	
B. Microtopography (mm)	**< 3**	**3–8**	**8–25**	**25–100**	**>100**	
	7	40	42	11	0	
C. Crust coherence	**Sand**	**Easily broken**	**Moderately hard**	**Very hard**	**Non-brittle or self-mulching**	
	11	43	14	22	10	
D. Cracking	**Extensively broken**	**Moderately broken**	**Slightly broken**	**Intact**		
	0	2	8	90		
E. Firmness	**Very loose**	**Loose**	**Moderately firm**	**Firm**		
	0	0	67	33		
F. Cryptogams (%)	**<1**	**1–10**	**10–50**	**> 50**		
	65	19	13	3		
G. Sheet erosion	**Extensive**	**Moderate**	**Slight**	**Insignificant**		
	0	3	23	74		
H. Soil cover (%)	**< 1**	**1–15**	**15–30**	**30–50**	**> 50**	
	11	31	30	21	7	
I. Basal cover (mm)	**< 7**	**7–70**	**70–140**	**> 140**		
	62	29	8	1		
J. Litter cover (%)	**< 10**	**10–25**	**25–50**	**50–75**	**75–100**	**100 (several cm thick)**
	14	26	38	15	5	2
K. Litter source	**Local**	**Transported**				
	100	0				
L. Litter incorporation	**Low**	**Moderate**	**Extensive**			
	71	12	17			
M. Texture	**Light Clay**	**Clay loam**	**Loam**	**Sandy loam**	**Sand**	
	2	8	18	43	29	

The CCA biplot (Fig. 8) indicated that a change in vegetation community from the *Callitris* Mixed Woodland (left hand side), to the White-top Grassland (bottom right) and Black Box Woodland (top right) can be described in terms of two environmental gradients: a gradient in surface soil texture and a gradient in organic carbon and litter cover. Map Units 1, 2, 3 and 6 were generally associated with coarser textured (sandier) soils with a wide range of soil and litter cover levels. Map Unit 5 was associated with increasing organic carbon (loamier soils) and increasing litter cover, whilst Map Unit 4 was associated with both increasing clay content and decreasing litter cover (Table 5, Fig. 8).

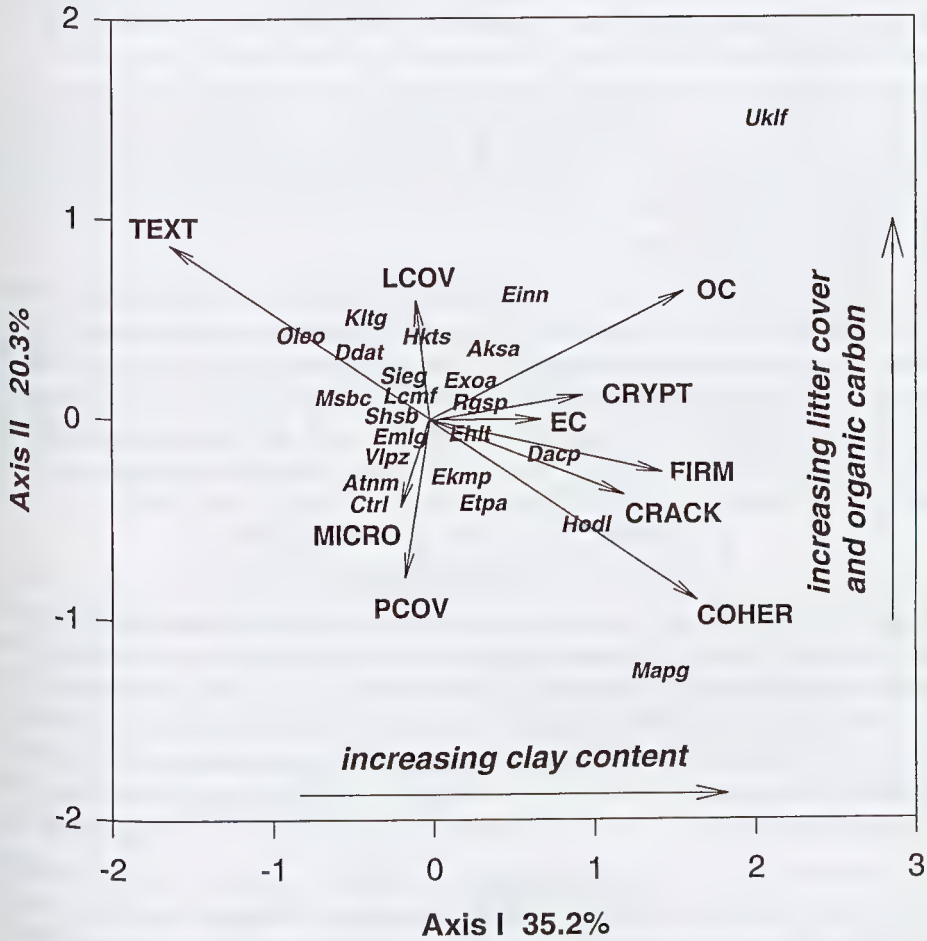

Fig. 7. Species-environment biplot for axes I and II after the Canonical Correspondence Analysis. Species names and codes are given in Appendix 2.

Soil chemical characteristics

Overall, the soils within the exclosure were non-saline ($EC_{1:5} < 0.40$ dS/m) and slightly acidic, with low percentages of organic carbon (Table 6). Electrical conductivity (EC) on Map Units 1, 2 and 3 were significantly lower than for Units 4 and 6 ($P < 0.05$), whilst Map Unit 5 was not significantly different to the other units.

Discussion

Floristics

Eighty-two percent (49) of the 60 sites in the 'Zara' exclosure corresponded to Porteners' (1993) *Callitris* Mixed Woodland, and the remainder corresponded with the Black Box Woodland and the White-top Grassland units. The *Callitris* Mixed Woodland had significantly greater species richness and diversity (Shannon-Weiner index) compared with the White-top Grassland and Black Box Woodland.

Consistent with other studies of the Riverine Plain and surrounding areas (Semple 1986, 1987, Porteners 1993, Sivertson & Metcalfe 1995), the Poaceae, Asteraceae, Chenopodiaceae and Fabaceae families were most represented (Table 2). Of the 977 species recorded for the Riverine Plain as a whole (Porteners 1993), 144 have been recorded at 'Zara' (Appendix 1)

The small number of species in common with other studies can be explained by two main factors. Firstly, the present study was conducted at only one point in time, during a very dry summer. Consequently, only summer-growing and/or drought tolerant plants were recorded. Further collections made during winter/spring or after rain are likely to increase the number of species recorded, particularly annuals and ephemerals. Secondly, as the exclosure is less than 60 hectares in area, it represents only a small proportion of the landscapes found over the Riverine Plain.

Relationships between soils and vegetation

In our study, the distribution of communities was closely associated with a range of environmental variables including soil texture, cracking, coherence, stability, organic carbon, plant cover and litter cover (Fig. 7). In general, the *Callitris* Mixed Woodland was associated with sandy, coarse-textured soils, the Black Box Woodland with loamier soils, and the White-top Grassland with finer clay-textured soils (Fig. 8). Soil texture, by influencing soil moisture availability, is known to be a critical determinant of species distribution (Noy-Meir 1974, Eldridge 1988).

Within the White-top Grassland, moisture availability is strongly influenced by the high clay content of soils (Williams 1956). Despite surface ponding, the high shrink swell capacity of clays limits the depth of water infiltration to approximately 30 cm (Eldridge 1988). Available water for plants is then limited by the high water holding capacity of the soils. Consequently, the vegetation within Map Unit 4 is dominated by short-lived ephemerals, perennial grasses and perennial shrubs such as *Maireana pentagona* which have shallow, lateral roots confined to the top 30 cm of the soil. The

limited water availability for plants, the difficulty for roots to penetrate the hardsetting soils (Williams 1956), the extensive cracking of the soil and the generally high salinity levels means that trees are generally restricted to either sandy rises, prior stream levees, or active watercourses (Semple 1990).

The combination of loamy soils with heavy clay subsoils, abundant litter and the probability of low water availability (due to the dense cover of *Eucalyptus largiflorens*), is probably responsible for the sparse plant cover in the Black Box Woodland sites (Table 5). Despite this sparse plant cover, compared with that in the *Callitris* Mixed Woodland (Fig. 8), the dense litter cover on these soils, a contribution from the upper canopy, is sufficient to protect the surface against raindrop impact, preventing soil slaking and surface sealing, and reducing overland flow of water and sediment movement. Litter also improves the condition of the soil by providing a source of organic matter, encouraging soil biota, leading to greater levels of porosity and therefore infiltration (Eldridge & Koen 1993).

In contrast to the clay soils, the earthy sands of the *Callitris* Mixed Woodland are highly permeable (Eldridge 1989), and characterised by low levels of organic carbon, and consequently low levels of electrical conductivity (Table 6). The deeper, sandier soils of the dune crest supported *Callitris glaucophylla* and shrubs such as *Dodonaea viscosa* which occur on sandplains and dune fields in the north-west of NSW at relatively high densities (Hodgkinson 1992). In sandy soils, a combination of relatively deeper penetration of water, and the availability of much of this moisture for germination, means that, compared with clay soils, sands respond much more rapidly to small falls of rain (Johns et al. 1984). As rainfall in the area is generally winter-dominant, much of the ephemeral growth at the time of the study is likely to be restricted to the sandy soils. This probably accounts for the relatively larger number of ephemeral species found on the sandy soils and perhaps the large numbers of weedy species compared with the clay soils.

Management of the 'Zara' exclosure

The Riverine Plain has been grazed by domestic livestock for more than 150 years, and is a severely modified landscape (Benson 1988). Fragmentation has left the exclosure isolated from other sandhills, and with a large perimeter across which exotic plants can penetrate. Monitoring of vegetation cover, invasion of exotics (both plants and animals) as well as soil health is an essential component of the management of 'Zara'. Strategies such as minimising disturbances in and around the exclosure to prevent the spread of exotics, and fencing of a buffer strip around the exclosure are likely to enhance the conservation value of the exclosure.

The present survey indicated that the vegetation communities at 'Zara' have already been substantially modified by the invasion of exotic weeds such as *Lycium ferocissimum*, and currently support relatively high abundances of common Mediterranean weeds such as *Citrullus lanatus* var. *lanatus*, *Mesembryanthemum crystallinum* and *Echium plantagineum*. Dispersal of these exotics is enhanced by disturbance by livestock and rabbits. Exotic plants influence the vegetation communities directly by their presence, and indirectly through competition with

Table 5. Soil surface variables and their distribution across the six Map Units.

Variables which changed little across the sites have been excluded. The modal (most common) value is in the first row, and the range of values, recorded for each Map Unit, in the second; 100+ for litter cover indicates 100% cover but several cm thick; mod. = moderately.

Map Unit	Texture	Crust coherence	Firmness	Microtopography (mm)	Cryptogam cover (%)	Soil cover (%)	Basal cover (%)	Litter cover (%)
1	**sand**	**easily broken**	**mod. firm**	**3 to 8**	**< 1**	**1 to 15**	**< 7**	**50 to 75**
	(sand to loam)	(sand to very hard)	(mod. firm to firm)	(< 3 to 100)	(< 1 to 50)	(< 1 to > 50)	(< 7 to 140)	(< 10 to 100)
2	**sandy loam**	**easily broken**	**mod. firm**	**8 to 25**	**< 1**	**1 to 15**	**< 7**	**25 to 50**
	(sand to sandy loam)	(sand to very hard)	(mod. firm to firm)	(< 3 to 100)	(< 1 to > 50)	(< 1 to > 50)	(< 7 to > 140)	(< 10 to 75)
3	**sandy loam**	**easily broken**	**mod. firm**	**3 to 8**	**< 1**	**15 to 30**	**7 to 70**	**10 to 25**
	(sand to sandy loam)	(sand to self mulching)	(mod. firm to firm)	(< 3 to 25)	(< 1 to 10)	(1 to > 50)	(< 7 to 140)	(10 to 75)
6	**loam**	**easily broken**	**firm**	**3 to 8**	**< 1**	**15 to 30**	**7 to 70**	**25 to 50**
	(sandy loam to clay loam)	(easily broken to self mulching)	(mod. firm to firm)	(< 3 to 100)	(< 1 to > 50)	(< 1 to > 50)	(< 7 to 140)	(< 10 to 100)
4	**clay loam**	**self-mulching**	**firm**	**8 to 25**	**1 to 10**	**30 to 50**	**< 7**	**25 to 50**
	(loam to clay)	(very hard to self mulching)	(firm)	(3 to 100)	(< 1 to 50)	(1 to 50)	(< 7 to 70)	(10 to 50)
5	**loam**	**easily broken**	**firm**	**8 to 25**	**10 to 50**	**1 to 15**	**< 7**	**25 to 50**
	(sandy loam to loam)	(easily broken to self mulching)	(mod. firm to firm)	(< 3 to 25)	(< 1 to > 50)	(< 1 to 50)	(< 7 to 70)	(< 10 to 100+)

Table 6. Differences in electrical conductivity (EC), organic carbon (OC) and pH between the six Map Units

	Map Units (number of sites)						
Variables	**1 (30)**	**2 (34)**	**3 (16)**	**6 (18)**	**4 (12)**	**5 (10)**	**Total (120)**
EC (dS m^{-1})	0.08 (0.02)[ab]	0.06 (0.01)[ab]	0.06 (0.01)[ab]	0.15 (0.04)[bc]	0.12 (0.01)[bc]	0.09 (0.02)[abc]	0.09 (0.01)
OC (%)	1.04 (0.11)[a]	1.01 (0.07)[a]	0.76 (0.04)[a]	1.31 (0.17)[a]	1.98 (0.11)[b]	3.16 (0.70)[c]	1.31 (0.09)
pH	6.45 (0.09)[a]	6.36 (0.04)[a]	6.43 (0.09)[a]	6.27 (0.10)[a]	6.21 (0.09)[a]	6.42 (0.04)[a]	6.37 (0.03)

Standard error of the mean is in parentheses. Values within a row with a similar superscript are not significantly different at $P = 0.05$. Electrical conductivity data were $\log_{10}$ transformed prior to ANOVA.

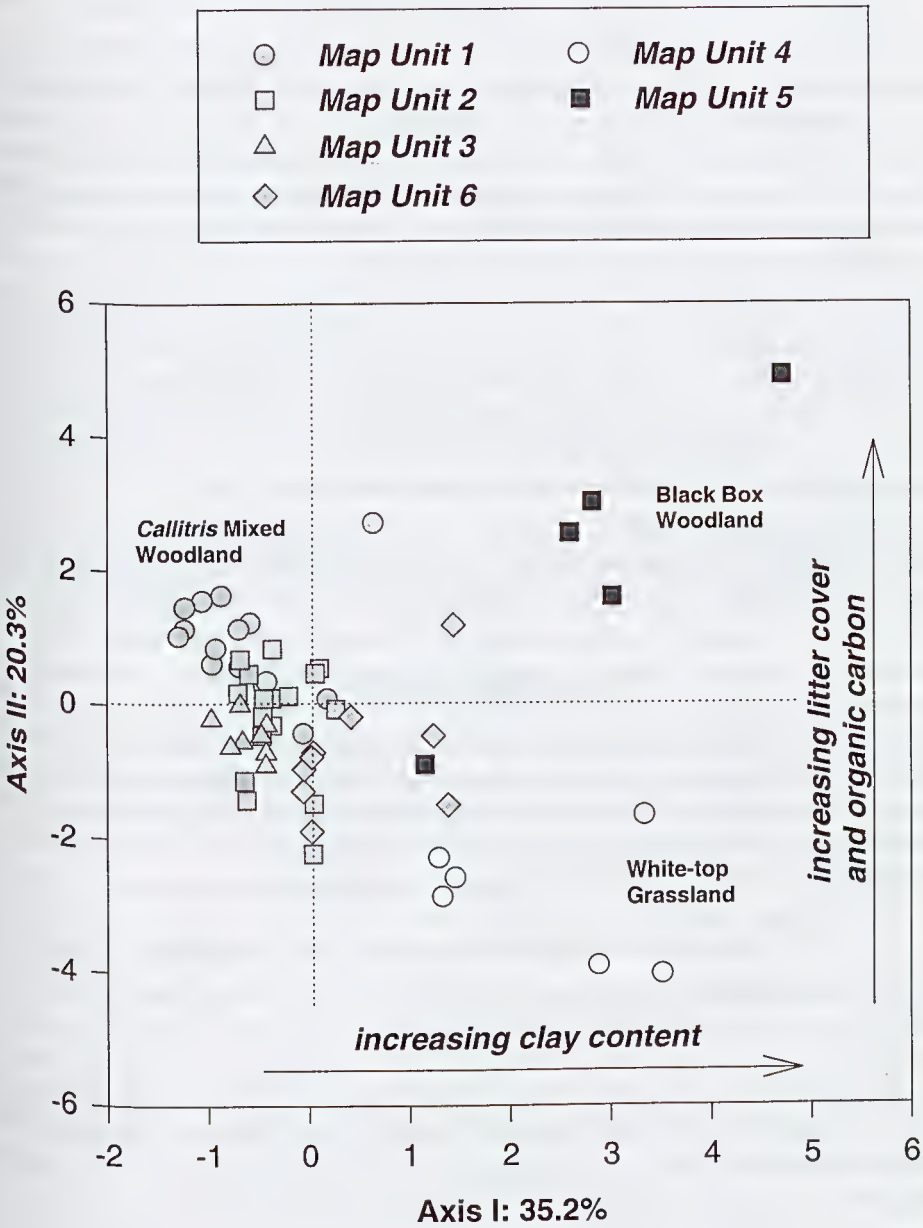

Fig. 8. Projection of the sample sites onto axes I and II of the species-environment biplot.

native species (McIntyre 1990). *Lycium ferocissimum* for example, poses a major threat to the exclosure through its capacity to rapidly invade, colonise and reproduce. *Lycium ferocissimum* provides a harbour for rabbits, and, as the seeds are readily eaten and dispersed by birds, it is present in most areas of the exclosure and dispersal is not restricted by fencing (Appendix 1). Physical removal, combined with the judicious use of herbicides and fire, appears to be an ecologically desirable control option.

Of greater concern in the long-term is the spread of exotic forbs and grasses which are more difficult to control. It is probable that forbs such as *Marrubium vulgare*, *Heliotropum* spp. and *Tribulus terrestris*, as well as the annual grasses *Avena* spp., *Lolium* spp. and *Bromus* spp. will prove a greater challenge for managers. Large areas of the Riverine Plain have already been invaded by exotic forbs and grasses, and their control in the exclosure is likely to be ongoing.

Since the construction of the exclosure in 1997, the Southern Riverina Naturalists have undertaken a rabbit control program using 1080 poison baits in conjunction with the ripping of warrens. As the regeneration of *Alectryon oleifolius* subsp. *canescens* is limited, and the regeneration of *Callitris glaucophylla* is rarely seen in the presence of rabbits or livestock, ongoing rabbit control is essential. Monitoring of rabbit warrens and regular examination of the fencing is recommended.

Control of wildfire has been identified as a contentious issue in the management of the 'Zara' exclosure. It is apparent from the present survey and anecdotal evidence, that the cover and density of shrubs such as *Rhagodia spinescens*, *Atriplex nummularia* and *Enchylaena tomentosa* have increased markedly over the past few decades and will continue to increase given the removal of stock. This may be associated with reductions in ground cover of perennial grasses and a reduced risk of wildfire. In the absence of controlled burning, large areas of the exclosure, particularly in the *Callitris* Mixed Woodland are likely to be converted from a grassland to a chenopod-dominated shrubland. One of the benefits of shrub increase is that the exclosure now provides a regular local seed source of native shrubs. These are collected and used extensively by Greening Australia in revegetation programs.

Conservation significance of the 'Zara' exclosure

The 'Zara' exclosure is an important example of the *Callitris* Mixed Woodlands which were once more common on aeolian landscapes on the Riverine Plain. Today this vegetation community is poorly conserved, threatened or vulnerable, due to inappropriate land use practices (Benson 1988, 1989, 1991, Eardley 1999). The *Callitris* Mixed Woodland at 'Zara' has a healthy understorey, and unlike many sandhills in the area, the community has retained part of its original shrub component (including *Atriplex nummularia* in Map Units 2 and 3).

Although not found in the present study, one ROTAP species *Ptilotus extenuatus* (Appendix 1, Briggs & Leigh 1996) was collected from the exclosure. *Ptilotus extenuatus* is now the only plant species presumed to be extinct on the Hay Plain, and despite numerous attempt to locate other specimens (Briggs & Leigh 1996) the species has not been recorded. *Calotis moorei*, a Schedule 1 species under the

Threatened Species Conservation Act was also collected at 'Zara' in the early 1900s (Short 1991). Additional species may be collected in the future following the exclusion of domestic and feral grazing animals.

The future of the 'Zara' exclosure

The present study provides a basis for future management strategies for sandhill remnants and monitoring programs. Being close to a large population centre (Deniliquin), the exclosure could serve as a focal point for community groups interested in learning more about semi-arid vegetation communities. Permanent sample points, already in place, can provide an invaluable baseline for future soil and ecological studies, and regular updating of the species lists by members of the Riverina Field Naturalists. The reserve can also provide ungrazed, benchmark sites to be incorporated into the Department of Land and Water Conservation's Rangeland Assessment Program. Future studies in the exclosure could include an examination of small mammal populations in relation to vegetation communities, temporal changes in plant communities after exclosure and recruitment of *Callitris glaucophylla* and *Alectryon oleifolius* after removal of sheep, rabbits and noxious shrubs.

The exclosure has the potential to complement other remnants and more formal conservation practices within the Riverina Bioregion (Eardley 1999). However, for it to be successful in the long term, it is important that it be incorporated into any future Land and Water Management Plans and Regional Conservation Plans for the area.

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Appendix 1: Species recorded for the 'Zara' enclosure, and the percentage of sites containing a particular speices within each of the six Map Units.

A = Mulham (unpub.); B = present study; + = species found; - = species not found; * = exotics; ! = ROTAP species; z = recorded by Short (1991).

Botanical Name	A	B	Map Unit (No. of sites) 1 (15)	2 (17)	3 (8)	6 (9)	4 (6)	5 (5)	Total (60)
PTERIDOPHYTES									
Adiantaceae									
Cheilanthes austrotenuifolia	+	+	.	6	.	.	.	.	2
Marsileaceae									
Marsilea drummondii	-	+	.	.	.	11	.	20	3
GYMNOPERMS									
Cupressaceae									
Callitris glaucophylla	+	+	80	29	25	.	.	.	32
ANGIOSPERMS-DICOTYLEDONS									
Aizoaceae									
**Mesembryanthemum crystallinum*	+	+	93	100	88	.	.	.	63
Amaranthaceae									
Alternanthera denticulata	+	-							
!Ptilotus extenuatus	+	-							
Apiaceae									
Daucus glochidiatus	+	-							
Asteraceae									
Actinobole uliginosum	+	+	13	12	.	.	.	.	7
**Arctotheca calendula*	+	-							
**Aster subulatus*	+	-							
Brachycome lineariloba	-	+	.	6	.	.	.	.	2
Calotis sp.	-	+	7	.	.	.	.	.	2
Calotis erinacea	+	-							
zCalotis moorei	-	-							
Calotis scabiosifolia	+	-							
Calotis scapigera	+	-							
**Carthamus lanatus*	+	-							
**Centaurea melitensis*	+	-							
Centipeda cunninghamii	+	-							
Chrysocephalum apiculatum	+	-							
**Chrysocephalum semipapposum*	+	-							
**Cirsium vulgare*	+	-							
**Cotula bipinnata*	+	-							
Eriochlamys behrii	-	+	.	.	.	.	.	20	2
**Hypochaeris glabra*	+	-							
Pseudognaphalium luteoalbum	+	-							
Senecio quadridentatus	+	+	13	.	.	.	.	20	5
**Sonchus oleraceus*	+	-							
Stuartina muelleri	+	-							
Vittadinia cuneata group	+	+	7	6	.	11	.	.	5
**Xanthium spinosum*	+	-							
Boraginaceae									
**Amsinckia intermedia*	+	+	13	.	13	.	.	.	5
**Echium plantagineum*	+	+	27	71	100	56	67	.	55
**Heliotropium europaeum*	+	+	7	12	.	11	.	.	7

Botanical Name	A	B	Map Unit (No. of sites)						
			1 (15)	2 (17)	3 (8)	6 (9)	4 (6)	5 (5)	Total (60)
Brassicaceae									
**Capsella bursa-pastoris*	+	-							
**Lepidium africanum*	-	+	60	29	63	67	.	60	47
**Sisymbrium erysimoides*	+	+	67	35	.	22	.	20	32
**Sisymbrium orientale*	+	-							
Campanulaceae									
Wahlenbergia sp.	+	+	7	12	.	.	.	.	5
Caryophyllaceae									
**Cerastium glomeratum*	+	-							
**Spergularia rubra*	+	+	.	.	.	.	.	20	2
Chenopodiaceae									
Atriplex leptocarpa	+	+	.	6	.	22	17	.	7
Atriplex nummularia	+	+	13	41	63	11	.	20	27
Atriplex pseudocampanulata	-	+	.	.	.	.	.	20	2
Atriplex semibaccata	+	+	.	.	.	22	50	20	10
Atriplex vesicaria	+	-							
Chenopodium nitrariaceum	+	+	.	6	13	22	.	20	8
Chenopodium pumilio	-	+	7	12	13	22	.	.	10
Einadia nutans	+	+	33	24	13	.	17	60	23
Enchylaena tomentosa	+	+	67	82	75	67	83	80	75
Maireana aphylla	+	+	.	.	.	.	33	.	3
Maireana decalvans	+	+	.	.	.	11	33	20	7
Maireana pentagona	+	+	7	6	.	.	100	40	17
Rhagodia spinescens	+	+	93	100	100	100	83	100	97
Salsola kali	+	+	7	41	.	33	.	20	20
Sclerolaena diacantha	-	+	.	6	.	.	.	.	2
Sclerolaena muricata	-	+	.	6	.	22	33	20	10
Convolvulaceae									
Convolvulus erubescens	+	+	7	6	.	11	.	.	5
Crassulaceae									
Crassula colorata var. *acuminata*	+	+	27	.	.	11	.	.	8
Cucurbitaceae									
**Citrullus lanatus* var. *lanatus*	+	+	20	18	13	11	.	.	13
Euphorbiaceae									
Chamaesyce drummondii	+	-							
Fabaceae-Caesalpinoideae									
Senna artemisioides	-	+	13	.	.	11	.	.	5
Senna artemisioides subsp. *coriacea*	+	-							
Senna artemisioides subsp. *filifolia*	+	-							
Fabaceae-Faboideae									
**Medicago polymorpha*	+	-							
**Medicago truncatula*	+	-							
Swainsona phacoides	+	-							
**Trifolium angustifolium*	+	-							
**Trifolium arvense*	+	+	20	47	100	44	.	20	40
Fabaceae-Mimosoideae									
Acacia oswaldii	+	+	.	.	25	11	.	20	7
Acacia pendula	+	+	.	.	.	.	17		2
Acacia salicina	+	+	20	.	38	22	.	20	15

Botanical Name	A	B	Map Unit (No. of sites) 1 (15)	2 (17)	3 (8)	6 (9)	4 (6)	5 (5)	Total (60)
Geraniaceae									
**Erodium cicutarium*	+	-							
Erodium crinitum	+	-							
Goodeniaceae									
Goodenia fascicularis	+	-							
Goodenia pinnatifida	+	-							
Goodenia pusilliflora	+	-							
Lamiaceae									
**Marrubium vulgare*	+	+	7	.	.	.	.	.	2
Teucrium racemosum	+	+	.	.	.	11	.	20	3
Loranthaceae									
Amyema quandang	+	-							
Lysiana exocarpi subsp. *exocarpi*	+	-							
Malvaceae									
**Malva parviflora*	+	-							
Sida corrugata	+	+	7	.	.	33	33	20	12
Myoporaceae									
Eremophila longifolia	+	+	27	47	88	44	17	20	42
Myoporum montanum	+	-							
Myoporum platycarpum	+	+	7	6	.	.	.	.	3
Myrtaceae									
Eucalyptus largiflorens	+	+	7	6	.	11	.	100	13
Eucalyptus largiflorens x populnea	+	-							
Nyctaginaceae									
Boerhavia coccinea	+	+	7	6	38	.	17	.	10
Oleaceae									
Jasminum lineare	+	+	53	12	63	11	.	20	28
Oxalidaceae									
Oxalis perennans	+	+	.	6	.	11	17	20	7
Pittosporaceae									
Bursaria spinosa subsp. *microphylla*	+	+	20	6	25	11	.	.	12
Pittosporum phylliraeoides	+	-							
Plantaginaceae									
Plantago sp.	+	-							
Polygonaceae									
Muehlenbeckia florulenta	+	-							
**Polygonum aviculare*	+	-							
Portulacaceae									
Calandrinia eremaea	+	-							
Portulaca oleracea	+	-							
Proteaceae									
Hakea leucoptera	+	-							
Hakea tephrosperma	+	+	60	35	13	33	.	.	32
Ranunculaceae									
Clematis microphylla var. *microphylla*	-	+	20	.	50	.	.	.	12
**Myosurus minimus*	+	-							
Ranunculus pentandrus	+	-							
Ranunculus pumilio	+	-							
Rubiaceae									
Asperula conferta	+	-							

Botanical Name	A	B	Map Unit (No. of sites) 1 (15)	2 (17)	3 (8)	6 (9)	4 (6)	5 (5)	Total (60)
Santalaceae									
Exocarpos aphyllus	+	+	73	59	50	33	.	80	53
Santalum acuminatum	+	+	20	.	.	.	.	.	5
Santalum lanceolatum	+	+	20	6	38	.	.	.	12
Sapindaceae									
Alectryon oleifolius subsp. *canescens*	+	+	53	29	13	.	.	.	23
Dodonaea viscosa subsp. *angustissima*	+	+	80	59	75	33	.	.	52
Solanaceae									
**Lycium ferocissimum*	+	+	60	59	38	44	.	80	50
Solanum esuriale	-	+	.	.	.	22	17	.	5
**Solanum nigrum*	-	+	7	.	.	.	.	.	2
Thymelaeceae									
Pimelea microcephala subsp. *microcephala*	+	+	7	6	.	11	.	.	5
Urticaceae									
**Urtica urens*	+	-							
Zygophyllaceae									
Nitraria billardieri	+	-							
**Tribulus terrestris*	-	+	7	6	13	.	.	.	5
ANGIOSPERMS-MONOCOTYLEDONS									
Cyperaceae									
Carex inversa	+	-							
**Cyperus eragrostis*	+	+	.	.	.	11	17	40	7
Eleocharis acuta	+	-							
Phormiaceae									
Dianella longifolia	+	+	.	6	.	.	.	.	2
Poaceae									
Agrostis avenacea var. *avenacea*	+	+	7	.	.	.	.	.	2
**Alopecurus geniculatus*	+	-							
**Avena fatua*	+	+	7	6	25	.	33	.	10
Bromus arenarius	+	+	87	88	100	78	17	20	75
**Bromus diandrus*	+	-							
**Bromus rubens*	+	-							
Chloris truncata	+	-							
Cynodon dactylon	+	-							
Dactyloctenium radulans	+	-							
Notodanthonia caespitosa	+	+	13	65	38	89	100	100	58
Elymus scaber var. *scaber*	-	+	.	.	.	11	50	40	10
Enneapogon nigricans	+	-							
Enteropogon acicularis	+	+	7	94	38	89	83	60	60
Eragrostis australasica	+	-							
**Eragrostis cilianensis*	+	-							
**Hordeum leporinum*	+	+	33	12	.	22	33	.	18
**Hordeum marinum*	+	-							
**Lolium rigidum*	+	+	.	.	.	.	50	.	5
Paspalidium constrictum	+	-							
**Schismus barbatus*	+	+	33	18	38	11	.	20	22
Sporobolus caroli	+	+	.	6	.	.	.	.	2
Stipa elegantissima	+	+	60	65	88	33	.	60	55
Stipa sp.	+	+	87	100	100	78	67	20	83
**Vulpia myuros*	+	+	73	12	88	89	17	.	48
Total no. of species	**129**	**77**	**54**	**51**	**35**	**46**	**26**	**36**	**77**

Appendix 2: Species names and codes (in alphabetical order) used in the cluster analysis and the Canonical Correspondence Analysis. * indicates an exotic species.

Code	Species
Aksa	*Acacia salicina*
Atnm	*Atriplex nummularia*
Atsm	*Atriplex semibaccata*
Avnf	**Avena fatua*
Bhvc	*Boerhavia coccinea*
Bmar	*Bromus arenarius*
Brss	*Bursaria spinosa* subsp. *microphylla*
Cazz	*Calotis* sp.
Chla	*Cheilanthes austrotenuifolia*
Ctrl	**Citrullus lanatus* var. *lanatus*
Dacp	*Notodanthonia caespitosa*
Ddat	*Dodonaea viscosa* subsp. *angustissima*
Ehlt	*Enchylaena tomentosa*
Ekmp	**Echium plantagineum*
Elms	*Elymus scaber* var. *scaber*
Emlg	*Eremophila longifolia*
Etpa	*Enteropogon acicularis*
Exoa	*Exocarpos aphyllus*
Hkts	*Hakea tephrosperma*
Hodl	**Hordeum leporinum*
Jsml	*Jasminum lineare*
Kltg	*Callitris glaucophylla*
Kppm	*Chenopodium pumilio*
Lcmf	**Lycium ferocissimum*
Leaf	**Lepidium africanum*
Mapg	*Maireana pentagona*
Msbc	**Mesembryanthemum crystallinum*
Oleo	*Alectryon oleifolius*
Rgsp	*Rhagodia spinescens*
Sacg	*Sida corrugata*
Sbme	**Sisymbrium erysimoides*
Semz	*Sclerolaena muricata*
Shsb	**Schismus barbatus*
Sieg	*Stipa elegantissima*
Sizz	*Stipa* sp.
Slml	*Santalum lanceolatum*
Slsk	*Salsola kali*
Tmav	**Trifolium arvense*
Uklf	*Eucalyptus largiflorens*
Vlpm	**Vulpia myuros*

Vegetation of the Guyra 1: 100 000 map sheet New England Bioregion, New South Wales

J.S. Benson and E.M. Ashby

Benson, J.S. and Ashby, E.M. (National Herbarium of New South Wales, Royal Botanic Gardens, Sydney, Australia 2000) 2000. The natural vegetation of the Guyra 1: 100 000 map sheet, New England Bioregion, New South Wales. Cunninghamia *6(3): 747–872.* The remnant natural vegetation (excluding native grasslands) of the Guyra 1: 100 000 map sheet area was sampled by way of 312 20 m × 20 m plots in which all vascular species were recorded using a modified Braun-Blanquet abundance rating. Sampling was stratified to cover the environmental factors of substrate, topographic position and altitude. Floristic analyses used the Kulczynski coefficient of dissimilarity in an agglomerative hierarchical cluster analysis and multidimensional scaling ordinations. Twenty-one plant communities were selected from the cluster analysis. The contribution of species to these groupings was investigated using a fidelity analysis. Another three communities were distinguished from aerial photographs and field traverse. These 24 plant communities are described and all except riparian vegetation are mapped. Their extent was mapped using aerial photography and ground traverses. The vegetation map was digitised at a scale of 1: 25 000 but has been reduced to 1: 100 000 for this publication. The minimum area mapped is 1 ha.

Eight hundred and eighty-nine plant taxa are reported for the study area, 681 of which were recorded during the survey. Common families are Poaceae, Asteraceae, Fabaceae, Myrtaceae, Orchidaceae and Cyperaceae. The status of the 28 nationally or State listed rare or threatened plant species, and other regionally rare species recorded in the area, is discussed. Some plant communities, such as those dominated by the stringybarks *Eucalyptus caliginosa* and *Eucalyptus laevopinea*, are ubiquitous in the landscape. Other communities are restricted in their geographic extent and contain a distinct suite of species. These included heath swamps, some forests on leucogranite and wetland vegetation in lagoons on basalt plateaux. 74% of the native woody vegetation has been cleared. This has particularly affected plant communities on higher nutrient soils including *Eucalyptus viminalis* and *Eucalyptus dalrympleana* subsp. *heptantha* open forest on basalt plateaux, *Eucalyptus nova-anglica* woodland in valleys, and *Eucalyptus blakelyi* and *Eucalyptus melliodora* woodland on sediments at lower altitudes. Most of the remnants have been grazed by stock thus influencing the understorey structure and species composition. Upright forbs and *Acacia* would appear to be less common now than prior to European settlement. Dieback of eucalypts over the last two decades has compounded the impacts of clearing. Logging and firewood cutting affects some plant communities. Weeds are most invasive where understorey disturbance is greatest, which is mainly in the small remnants on higher nutrient soil (basalt and sediments). Most of the lagoons in the study area have been drained or impounded, thus depleting wetland vegetation. Changes to fire regimes in the forest remnants may also have altered the populations of fire-dependent species. Most of the plant communities are poorly represented in conservation reserves. Conservation initiatives on private land are required to protect most of the communities. Key sites for conservation are listed.

Introduction

Approximately 60% of the woody vegetation in the New England bioregion of New South Wales has been cleared (Pressey et al. in press, Benson 1999). The Guyra 1: 100 000 map sheet is typical: more than 70% of the map sheet area has been cleared, but in a patchy way (Fig. 1). McIntyre and Barrett (1992) coined the term 'variegated landscape' to describe the New England countryside as it is composed of numerous patches of forest interspersed with cleared grazing country. Higher nutrient soils derived from basalt or alluviums have been most cleared, whereas large areas of vegetation growing on low nutrient soils derived from leucogranite in the region remain intact. Most of the understorey of forest remnants on private land have been extensively grazed over the last 130 years.

The aim of this project was to sample, document and map the extant native vegetation of the Guyra 1: 100 000 map sheet in the New England Bioregion. This will form a nucleus for further survey and mapping of the bioregion. This work concentrated on documenting the eucalypt-dominated open forests and woodlands (Walker & Hopkins 1990). We also surveyed and mapped shrublands, sedgelands and wetlands but did not survey or map natural or derived (Benson 1996) native grasslands. This work could be used to produce a pre-European vegetation map through further field survey and modelling (using methodology similar to that in Ferrier and Watson 1997 for example). However, by examining clearing patterns in the landscape, we provide estimates for the percentage remaining of each classified plant community.

Fig. 1. The New England Tableland Bioregion contains patches of forest of varying sizes scattered across a mainly cleared landscape.

The floristic data collected during this survey, along with the 1: 100 000 vegetation map (located inside the back cover) and the 1: 25 000 vegetation maps held on the geographic information system at the National Herbarium, will assist with land use planning in the study area. The data are particularly relevant for use in developing a regional vegetation plan under the Native Vegetation Conservation Act 1998.

Study area

The study area is defined by the Guyra 1: 100 000 map sheet (number 9237) on the Northern Tablelands (NT) botanical subdivision (Anderson 1961) of NSW (Fig. 2). It is located in the middle of the New England Bioregion (NEB) defined in Thackway and Cresswell (1995). Both regions are referred to in this paper. The main difference in the area covered by NT compared to NEB is that it includes western appendages along the Warrumbungle and Nandewar Ranges.

The Guyra map sheet is bounded by latitudes 30°30'S and 30°00'S and longitudes 151° 30'E and 152°00'E. The study area occupies approximately 2500 sq km and is bisected by the New England Highway running north-south along the Great Dividing Range. It is mainly within the Dumaresq and Guyra Shires with small proportions in the Uralla and Severn Shires. The area includes some of the higher parts of the Northern Tablelands of New South Wales. The town of Guyra is located centrally on a high basalt plateau, at the intersection of the New England Highway and the Ebor-Tingha roads. The northern part of the city of Armidale is on the southern boundary of the map area.

The study area contains some of the upper catchments of the eastern flowing Aberfoyle, Oban, Henry, Sara, Wollomombi and Gara rivers, and the western flowing Gwydir and McIntyre rivers. Altitudes range from 900 m in the south-east to above 1500 m on the Ben Lomond Range in the north.

The majority of the area is private land which is used principally for pastoralism. The more fertile, flat areas have been extensively cleared of native vegetation and native pastures have progressively been replaced with introduced pasture species that are reliant on fertilizers. Cropping is limited in extent due to the cold climate. There is increasing urbanisation of rural holdings closer to Armidale.

There are five conservation reserves totalling 1904 ha managed by the NSW National Parks and Wildlife Service. These cover only 0.72% of the study area. Parts of two small state forests (Armidale State Forest 230 ha and Avondale SF 220 ha) are also present, however Armidale State Forest is mostly a pine plantation.

Climate

The climate of the New England region is described in Hobbs and Jackson (1977). The region receives cold westerly or southwesterly winds in winter and mainly mild easterly winds in summer. Rain-bearing easterly winds, occasional cyclonic depressions and thunderstorms deliver maximum rainfall for the region in late spring and summer (Fig. 3). Some of this rain is high intensity, thus presenting an erosion hazard. Low pressure systems and cold fronts bring rain and occasionally snow in

winter, peaking in June. Regions at higher elevations receive higher rainfall in the study area. For example, Ben Lomond at 1360 m asl, receives an average of 1083 mm pa compared to Wandsworth at 1100 m asl which receives 827 mm and Armidale at 1000 m asl which receives 789 mm (Bureau of Meteorology 1996). A rainshadow exists in the valleys east of Armidale, including in the valley of the Wollomombi River that flows into the relatively dry Macleay gorges. Orographic factors increase precipitation on the ranges in the study area (such as Days Ridge and Mount Duval) that are exposed to moist easterly airstreams in summer.

Temperatures are warm in summer and cold in winter (Fig. 3). Summer temperatures are milder and winter temperatures colder than at locations at lower elevations

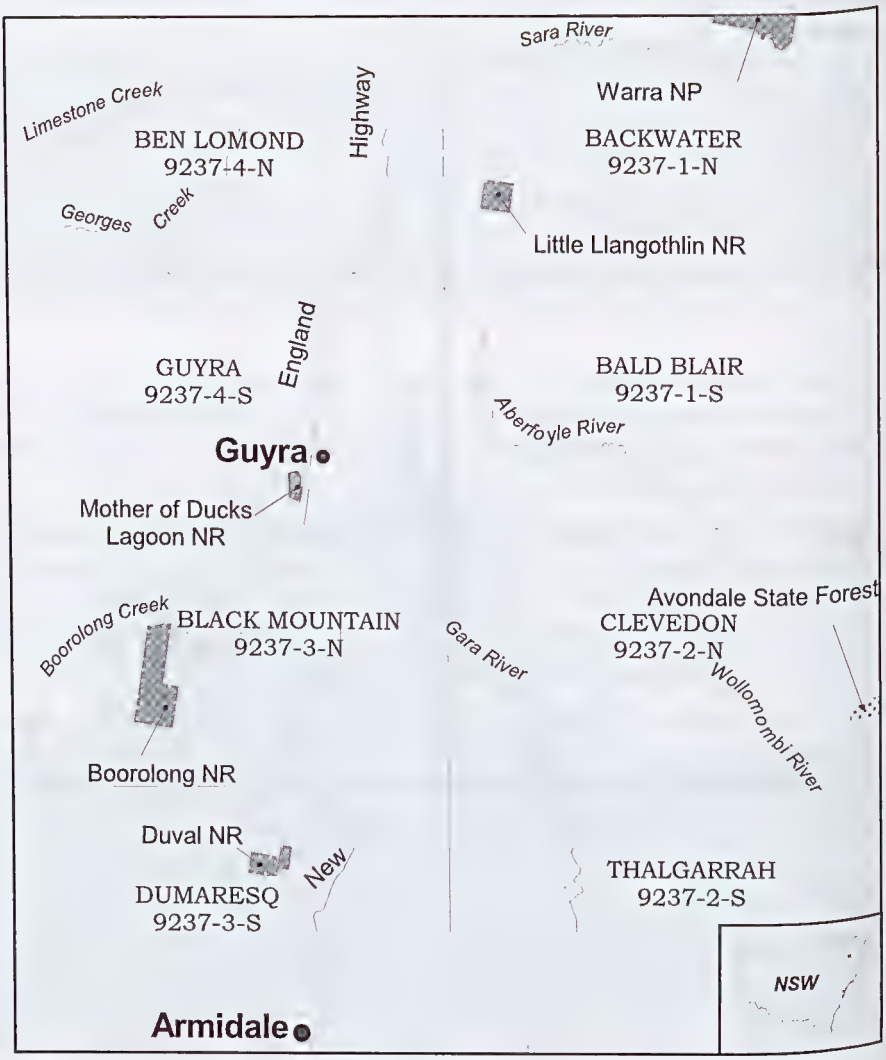

Fig. 2. Location of the Guyra 1: 100 000 map sheet, showing major rivers, conservation reserves, towns and the eight 1: 25 000 topographic maps that cover the area.

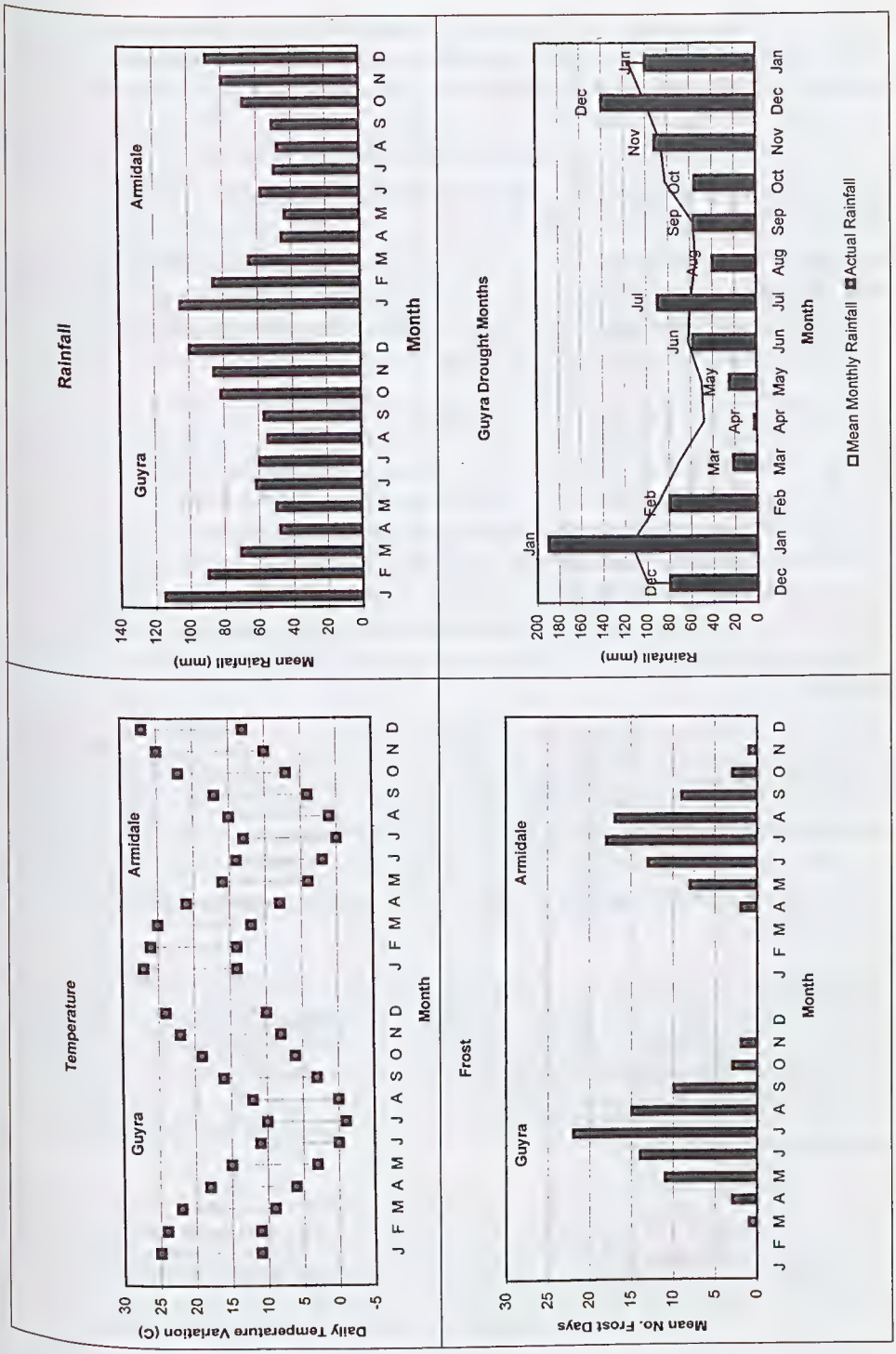

Fig. 3. Climate features of the towns of Guyra and Armidale including average monthly temperature, rainfall and frost days. Drought months for Guyra are shown for the period of field sampling, December 1992 to January 1994, by comparing the mean annual rainfall with actual rainfall for that period.

outside the study area on the Northern Tablelands or in adjoining regions. The high basalt plateau around Guyra is colder than lower parts such as Armidale. The latter has an average maximum summer temperature in January of 27°C compared to Guyra 24°C. Both have cold winters with an average minimum temperature in July of approximately zero. Frosts are common with an average of 20 frost days in Guyra and 17 in Armidale in July (Fig. 3). Cold air drainage affects most river valleys and hence the type of vegetation that occurs there.

Drought is less common on the tablelands than further west. The survey coincided with drought in eastern Australia and the study area was drought declared for 11 of the 14 months of the study period. During 1993, monthly rainfall fell below the average for nine out of the 12 months (Fig. 3).

Geology

The geology of the Northern Tablelands and adjoining coastal regions is depicted on the Dorrigo-Coffs Harbour 1: 250 000 geological map (NSW Department of Mines 1969). The Guyra 1: 100 000 map sheet is represented on the north-west corner of this map. Binns (1967) provides a summary of the geology and a geological map at 1: 250 000 scale covering the southern part of the New England Tableland including the Guyra region. A more accurate and detailed geological map covering the Guyra map sheet has been produced at a scale of 1: 100 000 by the NSW Department of Mineral Resources (1988).

The dominant structural feature of the Northern Tablelands is the New England Fold Belt, composed of a number of blocks of Paleozoic rocks including the New England Block (Harrington 1977, Rod 1974). These stratified rocks have been intensely folded and the strike line tends to follow the orientation of the major faults in the region, north to north west. A number of plutonic intrusions from the same era are present. Basalts from the Tertiary period overlay these rocks in parts of the region, particularly on the plateau between Guyra and Glen Innes.

In general, low elevations of the study area are composed of sedimentary or metamorphic rocks, while higher elevations tend to be composed of a range of granites, leucoadamellites (leucogranites) and Tertiary basalts. Acid volcanic rocks outcrop mainly west of the Great Dividing Range.

The Guyra 1: 100 000 geology map (Department of Mineral Resources 1988) shows the following main rock types:

- Metasediments of the Devonian Sandon Beds composed of lithic wacke, slate and chert cover much of the southern and south-western section of the study area;
- Devonian Uralla plutonic suite including the Mount Duval adamellite, Boorolong adamellite, Aberfoyle River porphyry and Llangothlin adamellite;
- Devonian and Permian leucadamellites in the Backwater-Oban River areas;
- Permian felsic volcanics (acid volcanics) in the north-western section of the area;
- Tertiary basalts on the plateau centred on Guyra and Ben Lomond, with outlying outcrops scattered over much of the rest of the area;
- Quaternary alluvials along rivers and in swamps.

A simplified geology map containing seven classes of substrate was developed by the National Parks and Wildlife Service in consultation with the NSW Geological Survey. This was used as one factor in stratifying the sampling of the vegetation of the study area.

Geomorphology

The Great Dividing Range runs north-south through the centre of the study area. It contains the upper catchments of both easterly and westerly-flowing river systems. Most of the landscape is undulating plateau broken by a number of higher ridges such as Mount Duval, Days Ridge and Mount Hourigan. An escarpment is present at the Devils Pinch separating the basalt plateau to the north from the Dumaresq Valley, mainly composed of sedimentary rocks, to the south.

On the top of the range on the basaltic plateau, the relief is small and the altitude high (up to 1509 m in the north at The Brothers). Lagoons are present in depressions on this plateau. More dissected country is found on the edge of the plateau where drainage lines have eroded the granites and leucogranites to the north east, the sediments and the granites of the south, and the acid volcanic rocks of the north-west. The altitude is still high in the valleys — down to a minimum of only 900 m along the Gara River in the south east. The most complex terrain is present on the leucogranite in the Backwater region where steep, rocky ridges are separated by valley flats, swamps and creek-lines.

The study area includes sections of five of the land provinces described by Morgan and Terrey (1990):

- Glen Innes-Guyra Basalts: occupying the central part of the study area, composed of rich soils on flat terrain at altitudes 1200–1500 m which has mostly been cleared;
- Armidale Plateau: in the south of the study area, mainly composed of sedimentary substrates of medium fertility at altitudes 900–1200 m;
- Wongwibinda Plateau: covering the south-eastern part of the area composed of sediments and basalts between 900–1100 m;
- Moredun Volcanics: in the north-western section of the area composed of acid volcanics and siliceous sedimentary substrates at altitudes 1000–1200 m;
- Nightcap Province: in the north-eastern section of the area mainly composed of leucogranites and granites with low soil fertility and hence containing the largest remnants of native vegetation.

Soils

Detailed descriptions of the soils of the New England Region, including the study area, are described and mapped in Jessup (1965), while Morgan and Terrey (1990) described soils of their land provinces on the New England Tableland.

The main soil associations in the study area are:

- Yellow podzolics and solodic soils, minor red earths and siliceous sands on sedimentary and metamorphic substrates in the vicinity of Armidale, Aberfoyle River and scattered localities elsewhere;

- Chocolate soils and krasnozems on ridges and weisenbodens in valleys on the basalt plateau at Guyra;
- Yellow sodolics on lower slopes and yellow podzolics on upper slopes on acid volcanics west of Guyra;
- Sandy yellow podzolics and gley podzolics on granites east of Llangothlin;
- Siliceous sands on upper slopes with gleyed podzolics in swamps on leucogranites near Backwater.

Gleyed solodic soils have a mottled B horizon with ironstone nodules in the A horizon. Podzolic soils have a contrast in texture with sharp boundaries between A and B horizons. Both solodic and podzolic soils are usually clayey. Chocolate soils on basalt are clayey with a mottled B horizon. Krasnozem soils on basalt are loamy gradational, reddish and well structured.

Land use history

Aboriginal occupation

At the time of European settlement the Anaiwan Tribe occupied much of the Northern Tablelands. Remaining physical evidence of these people's use of the Northern Tablelands includes rock shelters, camp sites, burials, ceremonial grounds, stone axes, axe grinding grooves (nearest at Tingha west of the study area) and art sites mainly under granite overhangs (Connah et al. 1977).

Aboriginal people lived in this area from at least 3000 B.C. This date is late compared to other regions of south-eastern Australia, either due to the cold post-ice age climate or because evidence of earlier occupation is lacking. It is likely that the cold, higher regions such as Guyra were sparsely populated and mainly used during the summer (Connah et al. 1977). This contrasts with evidence of larger populations on the nearby North Western Slopes.

Little is documented about how the Aborigines managed the land, as they were quickly displaced by the European invaders (Bowdler 1981). Explorers' notes of similar grassy woodland forest (for example, Mitchell 1848 referring to his crossing of the upper Hunter Valley in 1831) suggest that the understorey may have been burnt frequently for flushing game, stimulating growth of certain species and to ease access. This management regime may have reduced the number of saplings in the understorey, but there must have been sporadic regeneration events with appropriate climatic conditions. Aboriginal burning probably varied in different habitats. It was probably less frequent away from access routes and in the rougher granite and leucogranite regions of the study area. These areas contain shrubby species, many of which are in the same genera as the shrubs growing on Sydney sandstone that require variable fire regimes of between 8 and 25 years (Bradstock et al. 1995).

European exploration and settlement

A concise history of the early European explorations of the New England region is provided by Atchison (1977) and a history of the grazing industry is summarised in Nadolny (1998).

The first recorded European to traverse the Northern Tablelands was the Surveyor General John Oxley on his expedition of 1818 (Oxley 1820). The botanist Alan Cunningham accompanied Oxley.

The squatters moved in during the 1830s when Henry Dumaresq established the first pastoral run 'Saumarez' near modern-day Armidale. By 1839 pastoralists had moved north to Guyra (Atchison 1977). The large squatting runs withstood the threat of break up from the Robertson land acts in the 1860s. This legislation was designed to give free selectors the opportunity to take up and privatise land. An analysis of the impact of these acts on the New England pastoral runs revealed that the large pastoral runs mainly stayed intact (Ferry 1995).

It has been estimated that in the 1830s the Northern Tablelands were grazed by approximately 250 000 stock, with a stocking density of 0.6 sheep/ha (Campbell 1922 cited in Curtis 1989). By the late 1970s this increased to over 7 million, with 7 sheep/ha (Lodge et al. 1984) due to a combination of vegetation clearing and pasture improvement programmes (McDonald 1968 cited in Curtis 1989). Clearing would have been limited at first, but by 1890 about 10% of the Northern Tablelands had been ringbarked or cleared for grazing and cultivation. Curtis (1989) reports that teams of workers were employed on 'Saumarez' to ringbark and pull trees. Clearing was initially concentrated on the lower slopes and valleys where settlements were located. Lands close to mining areas were more intensively cleared. The two most active periods of clearing were 1870–1890 and after World War II. About 60% of the native tree cover has now been cleared across the Northern Tablelands (Benson 1999, Pressey et al. in press).

Pasture improvement, using a range of exotic grasses such as *Lolium perenne* and *Poa pratensis*, and legumes such as *Trifolium repens*, commenced in the 1920s but accelerated in the late 1940s. By 1973 19% of the region was sown to improved pasture. These imported grasses were aided in their establishment by the application of fertilizers, particularly superphosphate. Some of these pastures have been re-invaded by some native grasses and are termed natural pasture. Cultivation of crops has always been limited in extent.

Pre-European vegetation

At the time of European settlement the vast majority of the Northern Tablelands would have been covered in eucalypt forest and woodlands. Small patches of grassland would have occupied poorly-drained flats and river valleys that were affected by cold air drainage. Oxley (1820) observed and described a variety of forest vegetation. For example, he described travelling through 'the finest forest open country, or rather park, imaginable' (p. 291) as well as 'country … thickly timbered with stringybark and gum trees' (p. 293). However, Oxley's 'park-like' woodland

should not be interpreted as an 'open woodland' as defined in Walker and Hopkins (1990). Tree density estimates indicate grassy woodlands of south-eastern Australia contained on average about 30 large trees/hectare (Benson & Redpath 1997).

Armidale was built on a small open plain north of the larger Salisbury plain — an area of treeless or lightly wooded grassland. In 1838 John Everett noted plenty of stringybark in the region, peppermint in the valleys and on the open plains, and a range of wildlife including the Bustard (Curtis 1989). The botanist Campbell (1922) mentioned stringybarks monopolizing the slate ridges with peppermints and gums in the valleys. While the tree species distribution is similar to that of today (Williams 1985), albeit reduced in extent, the understorey has changed significantly in disturbed areas.

Comparing today's forests with that depicted in early descriptions (summarised in Curtis 1989), it would appear that the structure of the vegetation on the more fertile soils has changed. The open forests with well spaced, large trees noted by Oxley in 1818 and others, are now rare. Much of the forest today is regrowth from early clearing, being densely grouped and small in stature (Davidson & Davidson 1992).

It is likely, however, that the forests on the poorer soils (such as on the leucogranite near Backwater) are little changed.

Whalley et al. (1978) postulate there were three main types of grassland understorey in the region prior to European settlement. *Poa sieberiana* and *Themeda australis* dominated more fertile soils at high elevation, the same two species along with *Sorghum leiocladum* dominated on podsolic and solodic soils at lower elevations, and *Themeda australis*, *Aristida ramosa* and *Cymbopogon refractus* dominated on soils on well-drained, coarse grained granites. The most palatable *Themeda* and *Sorghum* grasses have been grazed out in many areas, while the less palatable snow grasses (*Poa* spp.) have persisted.

Previous botanical studies

Early botanical papers on the general region of the Northern Tablelands included Christie (1877) who commented on the relationship between plant species and the main substrates, Turner (1903) who prepared a plant species list and Cambage (1904) who reported on vegetation to the west of the tablelands. Turner's list shows that many exotic species were established in the region by the turn of the century. A more complete list of vascular plants on the New England Tablelands was prepared by Gray (1961), while Beadle (1971–1987) produced a Flora covering the north-eastern section of NSW. Norton (1971) dealt with the grasses of the region. Williams (1963) described the types of vegetation from the eastern scarp to the western slopes. Most of the vegetation on the Guyra 1: 100 000 map sheet is described as 'disturbed remnant' in the broad classification of Roberts (1992). The relatively intact vegetation near Backwater is described as 'plateau sclerophyll complex' in Roberts (1992). This classification was derived from LANDSAT TM images and covers the north-eastern region of NSW. McIntyre et al. (1993) documents understorey species in grassy forest on the New England Tablelands and discusses aspects of their rarity and sparseness.

More specific botanical surveys of locations in the study area include: Clarke (1980) who mapped and surveyed the vegetation on the Newholme Field Centre at Mount Duval; Binns (1992) who analyzed the forest communities of the state forests in the Glen Innes region including Warra State Forest; Brock and Britton (1994) who studied seedbanks of wetland plants in the basalt lagoons near Guyra; Tremont (1995) who investigated the phenologies of a range of native forbs near Armidale; and Hunter and Clarke (1998) who documented the vegetation growing on the granitic outcrops of the New England Batholith. Additionally, the University of New England has conducted student studies in various parts of the study area.

The natural pastures of the region have been the subject of considerable study beginning with Roe (1947), who suggested that native pastures should not be neglected because they are an important source of summer feed, and were so widespread. Subsequently, Lodge and Whalley (1989) described the native pastures of the region and commented on their management in relation to grazing and the application of fertilizer. Nadolny (1998) discusses the history of pasture use in the region, including the use of sown exotic species.

Methods

The project consisted of two components. Firstly, plot based sampling of the vegetation was undertaken to assist with predicting species occurrences and with the development of a floristic classification. This sampling targeted the main environmental classes of the study area (Keith & Bedward 1999, Benson 1995, Neldner 1993). It used outputs from a geographical information system to guide the development of the sampling programme. Secondly, the vegetation was mapped from aerial photographs and ground traverses. The vegetation map units are primarily based on the numerically-derived floristic classification developed from the plot data.

Floristic sampling

The vegetation was sampled across the entire map sheet based on a stratification of variables considered to influence vegetation — parent material (substrate), altitude (as a surrogate for rainfall and temperature), aspect and topographic position in the landscape. Digital layers were obtained under licence from NSW National Parks & Wildlife Service of tree cover, geology and altitude classes to aid in this process using the geographical information system Environmental Resource Mapping System (ERMS) (Ferrier 1988). The tree cover was determined from LANDSAT TM interpretation (Roberts 1992). No attempt was made to survey derived native grasslands in places where the original tree cover had been cleared.

The complex array of geological units mapped on published and unpublished geology maps for the region had previously been simplified by geologists from the Department of Mineral Resources in cooperation with National Parks and Wildlife Service staff. For the Guyra area there were initially seven of these derived geological categories: basalt (33%), granite (25%), acid volcanics (7%), leucogranite (6%), sedimentary (high quartz) (< 1%), sedimentary (low quartz) (27%) and Quaternary sand and alluvium

(1%). For the purposes of stratifying sampling, the two sedimentary geological categories were combined along with the Quaternary Sand and Alluvium to derive a geology map with five categories of substrate. This geology map is displayed on the vegetation map.

The tree cover data of Roberts (1992) was superimposed on these five substrates (Fig. 4). Approximately 20% of the map sheet was recorded with woody vegetation (> 20% crown cover) at the time of the study, based on the LANDSAT mapping (Roberts 1992). However, this did not include remnants less than 50 ha, natural swamps, open woodland and native grassland areas. Tree cover was distributed unevenly across geologies as different parent materials and landforms give rise to soils and landscapes with differing agricultural capability.

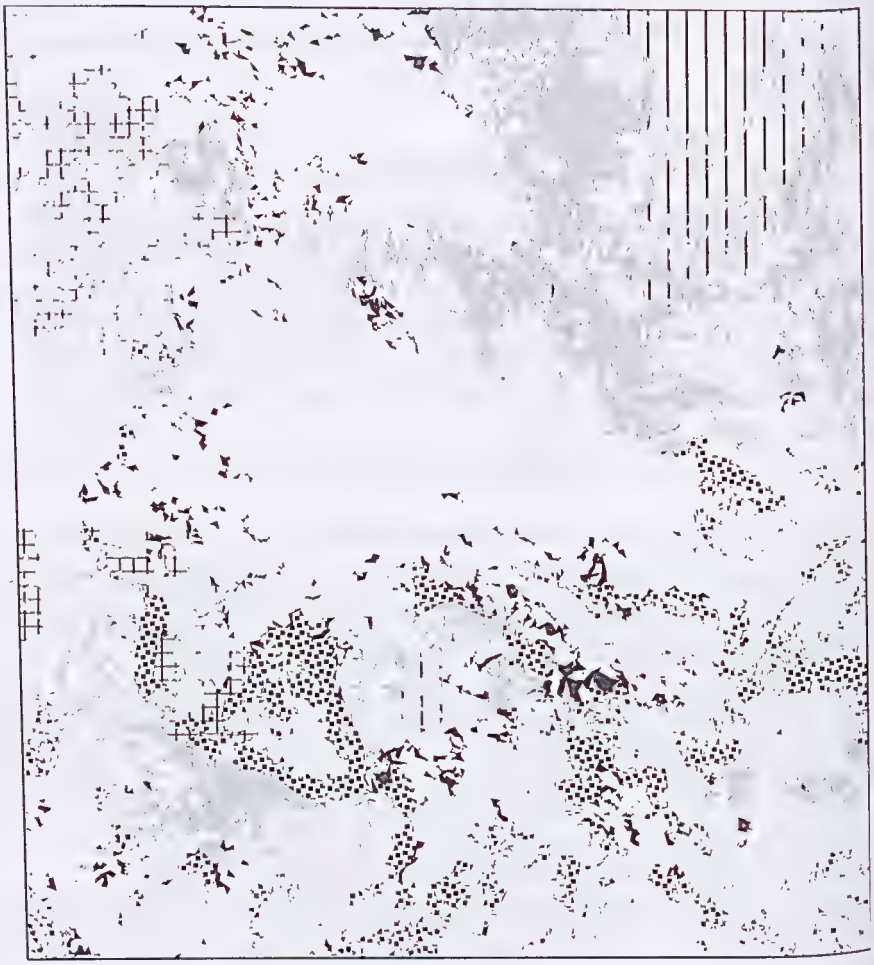

Fig. 4. Distribution of remnant vegetation detected from the LANDSAT TM image interpretation of Roberts (1992) over the five main substrates in the study area. Basalt = solid black, granite = light grey, leucogranite = vertical stripes, acid volcanic = checks, sedimentary = black blocks.

Using digitised terrain data in ERMS, altitude was classified into 6 bands: 900–1000 m, 1000–1100 m, 1100–1200 m, 1200–1300 m, 1300–1400 m, and > 1400 m. One category of slope was considered and aspect was considered to be of lesser importance to sample in parts of the study area with a gently undulating, basalt plateaux. Aspect was deemed to have a greater influence in the more dissected country at the mid-altitudes on non-basalt geologies.

The environmental cells and sampling requirements were developed by the following rules:

1. For landscape positions where aspect was irrelevant (ridge, flat and open depression) the number of sample sites was derived by multiplying five substrate types with six altitude classes by three replicates. This totalled 270.
2. For landscape positions requiring consideration of aspect (slopes greater than 5 degrees), the number of sample sites was derived by multiplying five substrate types with six altitude classes by four aspects by three replicates. This totalled 360.

The total number of sample sites required to sample all environmental cells defined in 1 and 2 above was 630 (sum of 1 and 2). However, it was found that considerably fewer sample plots were required in the field because some environmental cells were cleared (for example many sedimentary and alluvial areas), did not exist (for example, basalt at low altitudes), or existed very rarely and so could be discounted without great consequence (for example, low altitude granites).

Sampling intensity reflected the availability of vegetation on different geologies, with acid volcanics, basalt and leucogranites slightly over-sampled and granites and sedimentary and alluvium slightly under-represented (Table 1). Within the geology type, sample sites were spread across all available landscape positions (Table 2) and the sampling intensity tracked closely the relative availability of the various altitude classes (compare Table 2 with Table 1). Adequate replication and coverage of environmental cells was achieved by sampling a total of 312 sites. This included 12 sites in special habitats such as rocky outcrops and wetlands. Another consideration in the sampling stratification was geographic spread. In order to detect any geographic gradients, sample sites were spread across the map sheet where possible.

Sampling procedures

The vegetation was sampled in a total of 312 sites, each site being a 20 × 20 metre quadrat. This is a standard adopted by the National Herbarium of NSW as well as the NSW National Parks and Wildlife Service for coast and tablelands surveys (for example, Keith & Bedward 1999). The locations of these sites are shown on the vegetation map and details about them are stored on the flora survey database held by the Royal Botanic Gardens.

A total of 61 field days were spent by two person teams (i.e. 122 person days) to sample the vegetation. Twenty nine sites were sampled in December 1992, 36 in April 1993, 49 in October 1993, 117 in November 1993, and 80 in January 1994. Thus, in order to maximise the diversity of species recorded, sampling was spread across several seasons (spring, summer and autumn) and avoided the worst frost period May to

September (Fig. 3). However, at this time, the area was experiencing below average rainfall and the district was drought-declared for 11 of the 14 months of the study period (NSW Department of Agriculture pers. comm.). Plots were sampled once, so the plot data reflects the species present at one time.

All plant species were recorded in each quadrat and assigned a cover abundance based on a modified Braun-Blanquet 6-point scale (Poore 1955) (< 1%, 1–5%, 6–25%, 26–50%, 51–75%, 76–100%). The structure of the vegetation was also described by way of the number, type, height, crown cover and dominant species of each layer. A number of physiographic features were also noted for each site (slope, aspect, altitude, soil type, geology, azimuths) as well as an estimate of the degree and type of disturbance. Each site was located using a global positioning system device and verified and mapped on an aerial photo and 1: 25 000 topographic map for future reference.

Outside of the site sampling, the vegetation structure, dominant species and remnant size were also noted on topographic maps during extensive field traverses across the entire study area.

Plant species nomenclature conforms with that currently recognised by the National Herbarium of NSW and follows Harden (1990, 1991, 1992, 1993) and PlantNET (2000) for changes since Harden.

Table 1. Area (ha) of native vegetation remaining in each combination of geology and altitude compared with sampling intensity by geology (vegetation cover based on LANDSAT interpretation of Roberts 1992).

	Geology				
Altitude (m)	**Acid Volcanics**	**Basalt**	**Granites**	**Leucogranites**	**Sedimentary & Alluvium**
900–1000	0	0	69	166	416
1000–1100	10	648	1 091	2 334	5 687
1100–1200	2 475	1 067	3 218	4 121	5 912
1200–1300	2 400	1 690	4 414	3 621	5 054
1300–1400	317	1 777	8 066	455	274
1400 +	0	91	666	14	0
Total (ha)	**5 202** (9%)	**5 273** (9%)	**17 524** (31%)	**10 711** (19%)	**17 343** (31%)
No. of samples	**45** (14%)	**46** (15%)	**75** (24%)	**73** (23%)	**73** (23%)

Data analysis

All site data were entered into a relational database developed for vegetation data by NSW National Parks and Wildlife Service and used by the National Herbarium of NSW.

Data were investigated using multivariate techniques available in PATN (Belbin 1993) and unpublished software (Bedward pers. comm.). Floristic groups were determined by analysing presence/absence and cover abundance data. We selected the output generated by cover abundance data for the reasons outlined below.

Table 2: Number of sites sampled in each combination of environmental attributes. -= not sampled for reasons outlined in text.

Geology	Altitude (m)	Special Habitats	Ridge	Flat	Open Depression	North-facing Slope	East-facing Slope	South-facing Slope	West-facing Slope	Total
		Landscape position and aspect								
Acid Volcanics	900–1000	-	-	-	-	-	-	-	-	**0**
	1000–1100	-	-	-	-	-	-	-	-	**0**
	1100–1200	-	4	3	2	2	3	1	3	**18**
	1200–1300	-	5	2	-	4	4	3	2	**20**
	1300–1400	-	3	-	-	-	1	1	2	**7**
	1400 +	-	-	-	-	-	-	-	-	**0**
	Sub-total	**0**	**12**	**5**	**2**	**6**	**8**	**5**	**7**	**45**
Basalt	900–1000	-	-	-	-	-	-	-	-	**0**
	1000–1100	-	1	1	-	-	-	-	2	**4**
	1100–1200	-	3	1	-	1	1	1	1	**8**
	1200–1300	-	2	-	1	-	2	1	1	**7**
	1300–1400	7	2	4	-	2	2	3	-	**20**
	1400 +	-	4	-	-	1	1	1	-	**7**
	Sub-total	**7**	**12**	**6**	**1**	**4**	**6**	**6**	**4**	**46**
Granite	900–1000	-	-	-	-	-	-	-	-	**0**
	1000–1100	-	1	1	2	2	-	2	2	**10**
	1100–1200	-	3	4	2	1	3	3	3	**19**
	1200–1300	-	3	1	1	3	5	1	4	**18**
	1300–1400	2	5	1	-	2	4	3	4	**21**
	1400 +	-	2	-	-	2	1	1	1	**7**
	Sub-total	**2**	**14**	**7**	**5**	**10**	**13**	**10**	**14**	**75**
Leucogranite	900–1000	-	-	-	1	-	-	-	-	**1**
	1000–1100	-	3	4	3	2	2	3	3	**20**
	1100–1200	-	2	2	-	3	4	3	2	**16**
	1200–1300	3	3	4	2	3	3	3	3	**24**
	1300–1400	-	5	1	-	1	3	1	-	**11**
	1400 +	-	1	-	-	-	-	-	-	**1**
	Sub-total	**3**	**14**	**11**	**6**	**9**	**12**	**10**	**8**	**73**
Sedimentary & Alluvium										
	900–1000	-	-	2	-	-	-	1	1	**4**
	1000–1100	-	5	5	1	2	3	5	4	**25**
	1100–1200	-	4	2	1	3	6	3	4	**23**
	1200–1300	-	5	3	1	3	1	3	4	**20**
	1300–1400	-	1	-	-	-	-	-	-	**1**
	1400 +	-	-	-	-	-	-	-	-	**0**
	Sub-total	**0**	**15**	**12**	**3**	**8**	**10**	**12**	**13**	**73**
	Total	**12**	**67**	**41**	**17**	**37**	**49**	**43**	**46**	**312**

Presence/absence data are suitable to use where there are highly heterogeneous areas of vegetation to be classified (Lambert & Dale 1964, Orloci 1968), for example where there are variable ephemeral species such as in semi-arid herbfields and grasslands. For these reasons Benson et al. (1997) used presence/absence data in their analysis of the native grasslands of the Riverina. However, in less heterogeneous stands of vegetation, cover abundance data can assist classification (Goodall 1980). Cover abundance data provide a quantitative contribution of species dominance to a classification. This can deliver classifications that reflect ecological difference in places where perennial species comprise a high proportion of total species present. This would include most of eastern New South Wales. Faith et al. (1987) warn that abundance data can overly influence dissimilarities, although they also state that abundance data can minimise the impacts of sporadic or 'noisy' species which do not attain high abundances.

A hierarchical agglomerative classification was used to describe groupings of species and sites and their relationship to environmental features (Belbin 1991). The Kulczynski coefficient of dissimilarity was used. This coefficient is superior in ecological applications (Belbin 1993) because it describes the dissimilarity between sites based on their shared species composition and places no emphasis on the absence of species. This is particularly relevant in a fragmented landscape where species may be absent due to disturbance rather than due to an inherent likelihood of occurrence, or seasonal differences in time of sampling.

The homogeneity of the group associations was investigated using homogeneity analysis as presented in Bedward et al. (1992). A hierarchical classification of sites was then derived from a clustering strategy using a Beta value of -1 in a flexible unweighted pair group arithmetic averaging (UPGMA).

To check for misclassified sites in the resultant groups, a checking routine of nearest neighbours (Bedward, unpublished software) was used. This examines the nearest neighbours of all sites (as measured in the association matrix) and assesses whether any given site is grouped with its nearest neighbours. A misclassified site is one in a group where none of that site's nearest neighbours are present, and where none of the other sites in the group has that site as a nearest neighbour.

Once the classification was checked to conform with these criteria, the resulting dendrogram was investigated for environmental descriptors. The relationship between floristic composition and environmental variables was examined using a semi-strong hybrid multidimensional scaling ordination in two dimensions (SSH), as discussed in Belbin (1991, 1993) and Faith (1991).

Five environmental attributes were chosen for further investigaiton: altitude, geology, aspect, geographical position and topographical position. Although many other variables were recorded at each site (e.g. fire history, grazing pressure), these 5 were chosen as they were objectively measured and mappable. Categorical data of geology, slope and aspect were converted to continuous data. Geology was coded as an index for increasing nutrient status from 1 (poorest) to 5 (richest): leucogranite, acid volcanic, granite, sedimentary and basalt. Aspect and topographic position were coded as an

index reflecting increasing exposure. A vector for each variable was fitted in the ordination using principal axis correlation (Belbin 1993). This produces a correlation coefficient measuring the fit of the vector with the association measures in ordination space. As few biological data conform to linearity along an environmental attribute gradient, the significance of a correlation coefficient is difficult to determine. In this case we used a Monte Carlo procedure for 1000 iterations, where correlation coefficent is recalculated for each randomisation. Thus, the significance of the original result is measured against the set of correlation coefficients possible from the data set.

Once the floristic groupings were finalised, a measure of fidelity to those groupings was generated for each species within that group (Bedward, unpublished software) to elucidate the contribution each species made to the definition of the group. The algorithm of Bedward follows the approach of Westhoff and van de Maarel (1980). It relates maximum proportion of occurrence of the species in any group to the sum of all proportions of occurrences in all groups. Species were selected as being indicators of each floristic group (plant community) when fidelity was set at a minimum of 0.8 and species occurred in at least 50% of sites within that group.

Vegetation mapping

Native vegetation was mapped at 1: 25 000 scale using the numerically-derived floristic groups as the basis for the map units. Aerial photo interpretation was undertaken only after the numerical analysis. This method contrasts with traditional vegetation mapping where patterns discerned by API have usually dictated the field sampling program and the definition of plant communities.

Colour aerial photographs at 1: 25 000 scale dated September 1989 (Land Information Centre 1989) were used to delineate native vegetation (excluding native grasslands) and to extrapolate vegetation patterns across the landscape. More recent aerial photography or satellite imagery were not analysed to ascertain recent clearing. Our observations suggest that only small areas were cleared during the 1990s, compared with the 1980s. A LANDSAT TM analysis of clearing in NSW from 1995–1997 detected less than 50 ha of clearing in the Guyra 1: 100 000 map sheet area (Environmental Research and Information Consortium 1998). If recent clearing was observed during field traverses, the map was modified. Recent ringbarking was mapped as cleared land, although in some places regrowth was occurring.

There was extensive field checking in February 1998 of the initial markup of vegetation units on the aerial photographs. All major and minor roads (including many farm tracks) were traversed.

Digital data for terrain, cultural features and drainage for all eight 1: 25 000 topographic map sheets that cover the Guyra 1: 100 000 map sheet were obtained from the Surveyor General's Department. 'Master positives' were produced from these data on archival matte film. A transfer scope was used to transfer the vegetation map unit boundaries from the aerial photographs to these master positives. The vegetation polygons were then digitised into ERMS and transferred into ArcView for analysis and presentation. Polygons were captured at 1: 25 000 scale and reduced to 1: 100 000 for the published

map. Users of the 1: 100 000 map should be aware that the data exist at a larger scale and that hardcopies of 1: 25 000 maps can be issued on request.

Multi-attribute codes for typing the structure and floristics of the vegetation were applied. These were based on the structural classification of Walker and Hopkins (1990) and the codes used by the NSW NPWS (1995) in mapping the vegetation of upper north-eastern NSW. At sample sites we recorded actual measurements of height and density for each vegetation stratum. These site data assisted with applying attribute codes to each polygon delineated on the aerial photographs. These attribute codes are not shown on the printed map but can be generated from the GIS map coverage. The attributes assigned were:

- Height: 1 = > 25m; 2 = 12–25 m; 3 = < 12 m;
- Crown cover: a = < 10%; b = 10–30%; c = 30–50%; d = 50–80%; e = > 80%;
- Plant community number developed from the UPGMA classification, API or by field observation;
- API canopy disturbance categories:
  u = undisturbed
  d = estimated up to 25% thinned and/or lightly grazed;
  D = estimated 25–50% thinned/cleared and/or heavily grazed;
  s = scattered trees between 50% and 70% cleared and heavily grazed;
  A = > 70% cleared - agricultural land;
- API ground cover disturbance categories:
  y = natural ground cover (estimated to contain > 50% native plant cover);
  x = exotic ground cover.

An example of a composite code in a polygon is 2c17dy. This implies it is an open forest (2c), composed of plant community number 17 *Eucalyptus obliqua-Eucalyptus nobilis* (Messmate-Forest Ribbon Gum), which has been lightly disturbed (d), and has a native ground cover (y).

To assign an estimate of thinning, assumptions had to be made about the pre-European canopy. We assumed that the pre-European canopy of forests in the region were between one and two tree crown widths apart in valleys that contain medium to high nutrient soils (Benson & Redpath 1997, Curtis 1989) with denser (touching) crowns on steeper slopes and siliceous ridges. Canopy disturbance does not necessarily correspond to an equivalent degree of disturbance of lower strata.

The minimum sized remnant mapped is 1 ha. This is difficult to discern on the 1: 100 000 map sheet, but is quite visible at the 1: 25 000 scale. Small clumps of isolated trees in land that has been > 70% cleared are not delineated. Also, derived native grasslands (grasslands remaining after removal of woody canopy species) are not shown on the vegetation map.

The mapped plant communities closely reflect the floristic groups generated in the UPGMA. Some plant communities, such as New England Peppermint (*Eucalyptus nova-anglica*), swamps and wetlands were easily discernible from aerial photographs. Others, such as the four communities (2–5) composed of open forest dominated by various species of stringybark were difficult to separate. They were distinguished

using site data and field traverse. As we could not field check every remnant, errors are likely to be present in the extrapolation of some communities across the landscape using API.

Riparian Shrubland (plant community 23), is restricted to narrow strips along watercourses and is not shown on the map. API was used to split *Eucalyptus stellulata* (Black Sallee Woodland, plant community 7) from *Eucalyptus viminalis-Eucalyptus dalrympleana-Eucalyptus pauciflora* (Ribbon Gum-Mountain Gum-Snow Gum Open Forest, plant community 6). API and ground traverse distinguished *Eucalyptus acaciiformis-Eucalyptus caliginosa-Eucalyptus radiata* subsp. *sejuncta* (Wattle-leaved Peppermint-Broad-leaved Stringybark-Narrow-leaved Peppermint Open Forest, plant community 19) from *Eucalyptus caliginosa* (Broad-leaved Stringybark Open Forest plant community 2) in the Avondale Road area north-east of Armidale. Using API and substrate, the poorly sampled and depleted *Eucalyptus nova-anglica* New England Peppermint occurring on basalt (plant community 8) was split from other New England Peppermint forests occurring on leucogranites/granites (plant community 10) and sediments/acid volcanics/western granites (plant community 9).

Exotic pine plantations and stands of poplar trees on farms were delineated on the aerial photographs but were not transferred to the vegetation maps.

The pre-European extent of the plant communities in the study area has not been accurately mapped or modelled. However, it has been estimated by examining the relationship of the extant distribution of plant communities with landscape position and substrate, and extrapolating this to cleared areas. This was done by comparing the 1:25 000 topographic maps and the simplified geology map with the current distribution of the vegetation shown on the vegetation map. The pre-European extent of the plant communities was extrapolated over the geology, landforms and geographical locations most likely to have contained them. Aerial photographic interpretation along with field notes recorded during ground traverse assisted with these estimates. The pre-European extent of community 24 (basalt lagoons) was estimated by examining the topographic maps that depict most of the past (drained) and present lagoons.

Assessing the threat and reservation status of plant communities

Criteria for assessing the threat status of ecological or plant communities have been developed by Benson (1989), Hager and Benson (1994), Sattler and Williams (1999), English and Blyth (1999) and Environment Australia (2000). The remaining extent threshold criterion based on Benson (in review) and Environment Australia (2000) was used to assign a threat category to each plant community. This required comparing the GIS calculated measurement of the area of each plant community (excluding the unmapped riparian vegetation — community 23), with estimates of the proportion that had been cleared. These estimates were derived by examining clearing patterns in relation to landforms and existing remnants.

The threat codes used are:

CE = 'critically endangered' implies that:

- it was a 'common' plant community at the time of European settlement (> 10 000 ha) and that > 90% of it has been cleared or severely degraded, or
- it was a 'naturally restricted' plant community (> 1000 < 10 000 ha original extent) and that > 80% of it has been cleared or severely degraded, or
- it was a 'rare' plant community at the time of European settlement (< 1000 ha original extent) and that > 70% of it has been cleared or severely degraded.

E = 'endangered' implies that:

- it was a'common'plant community at the time of European settlement (> 10 000 ha) and that 70–90% of it has been cleared or severely degraded, or
- it was a 'naturally restricted' plant community (> 1000 < 10 000 ha original extent) and that 60–80% of it has been cleared or severely degraded, or
- it was a 'rare' plant community at the time of European settlement (< 1000 ha original extent) and that 50–70% of it has been cleared or severely degraded.

V = 'vulnerable' implies that:

- it was a'common'plant community at the time of European settlement (> 10 000 ha) and that 50–70% of it has been cleared or severely degraded, or
- it was a 'naturally restricted' plant community (> 1000 < 10 000 ha original extent) and that 40–60% of it has been cleared or severely degraded, or
- it was a 'rare' plant community at the time of European settlement (< 1000 ha original extent) and that 30–50% of it has been cleared or severely degraded.

NT = 'near threatened' implies that:

- it was a'common'plant community at the time of European settlement (> 10 000 ha) and that 35–50% of it has been cleared or severely degraded, or
- it was a 'naturally restricted' plant community (> 1000 < 10 000 ha original extent) and that 25–40% of it has been cleared or severely degraded, or
- it was a 'rare' plant community at the time of European settlement (< 1000 ha original extent) and that 15–30% of it has been cleared or severely degraded.

LC = 'least concern' implies that:

- it was a'common'plant community at the time of European settlement (> 10 000 ha) and that < 35% of it has been cleared or severely degraded, or
- it was a 'naturally restricted' plant community (> 1000 < 10 000 ha original extent) and that up to 25% of it has been cleared or severely degraded, or
- it was a 'rare' plant community at the time of European settlement (< 1000 ha original extent) and that up to 15% of it has been cleared or severely degraded.

A reservation status code is assigned to each plant community for the study area. This is based on the proportion of the pre-European extent of each plant community that is represented in conservation reserves. The extant area of each plant community in reserves is calculated from the GIS, while the pre-European extent is an estimate. The reservation codes are based on the area reserved classes of Hager and Benson (1994):

- **VP** = 'Not or very poorly reserved' (i.e. < 1%);
- **P** = 'poorly reserved' (1–5%);
- **M** = 'moderately well conserved' (5–10%);
- **AC** = 'adequately conserved' (10–25%);
- **EC** = 'exceptionally well conserved' (> 25%).

State and national assessments of the threat and reservation status of the plant communities would be realised with further mapping of vegetation outside the study area, and modelling of its pre-European extent.

Results

Data Analysis

The dendrogram derived from the Kulczynski association and UPGMA clustering analysis (adjusted for misclassifications), is shown in Fig. 5. Twenty-one plant communities were defined at the dissimilarity measure of 0.7. Homogeneity analysis of these groups based on floristic composition reveals that 21 groups coincides with the first turning point of the homogeneity curve (Fig. 6). This is a desirable level of grouping because past this point there is less relative gain in homogeneity for further group definition i.e. the solution becomes less efficient (Bedward et al. 1992).

Major increases in homogeneity correspond with primary divisions in the dendrogram. At the first split of the dendrogram (and the first major increase in homogeneity), the forest and woodland groups pull away from the swamp, lagoon, river, scrub and rocky outcrop groups. The next significant point of division delineate the open forests of the leucogranite and granite geologies from the forest and woodlands of other geologies.

At a dissimilarity measure of approximately 1.0, 10 major groups are defined in the dendrogram and 70% of the homogeneity described by 21 groups has been reached.

These relationships were further investigated with ordination using Semi-Strong Hybrid- Multi-Dimensional Scaling in the PATN package (Fig. 7). Vectors fitted for easting (0.518), northing (0.691), nutrient rating (0.671) and altitude (0.484) were all significant at $p < 0.01$. Aspect (0.379) and topographic position (0.228) were significant at $p < 0.02$.

These numerical analyses revealed 21 floristic groups in 10 major groupings that were responding to a combination of environmental factors such as substrate, altitude and geographical position (the last two probably acting in concert as a surrogate for rainfall), together with availability of special habitat niches such as rocky outcrops and closed depressions (illustrated on Fig. 8). The floristic groups form the bulk of the vegetation units that are mapped. They are described in detail in a later section, but broadly, the 10 major groups delineated are:

1. Open forests on sedimentary substrates at mid-low altitudes with Blakely's Red Gum (*Eucalyptus blakelyi*) with Yellow Box (*Eucalyptus melliodora*) on lower slopes and Broad-leaved Stringybark (*Eucalyptus caliginosa*) on ridges (communities 1, 2, 19);
2. Open forests composed of Silver-topped Stringybark (*Eucalyptus laevopinea*) on various geologies at slightly higher altitudes than 1 above (communities 3 and 4);
3. Open forests composed of Youmans Stringybark (*Eucalyptus youmanii*) and *Eucalyptus subtilior* with Western New England Blackbutt (*Eucalyptus andrewsii*) on acid volcanic geology (community 5);
4. Tall open forests and open forests composed of Ribbon Gum (*Eucalyptus viminalis*), Snow Gum (*Eucalyptus pauciflora*), Black Sallee (*Eucalyptus stellulata*), Mountain Gum (*Eucalyptus dalrympleana* subsp. *heptantha*) on basalt plateaux, and New England Peppermint (*Eucalyptus nova-anglica*) open forest and woodland in valleys on various substrates subjected to cold air drainage (communities 6–10);

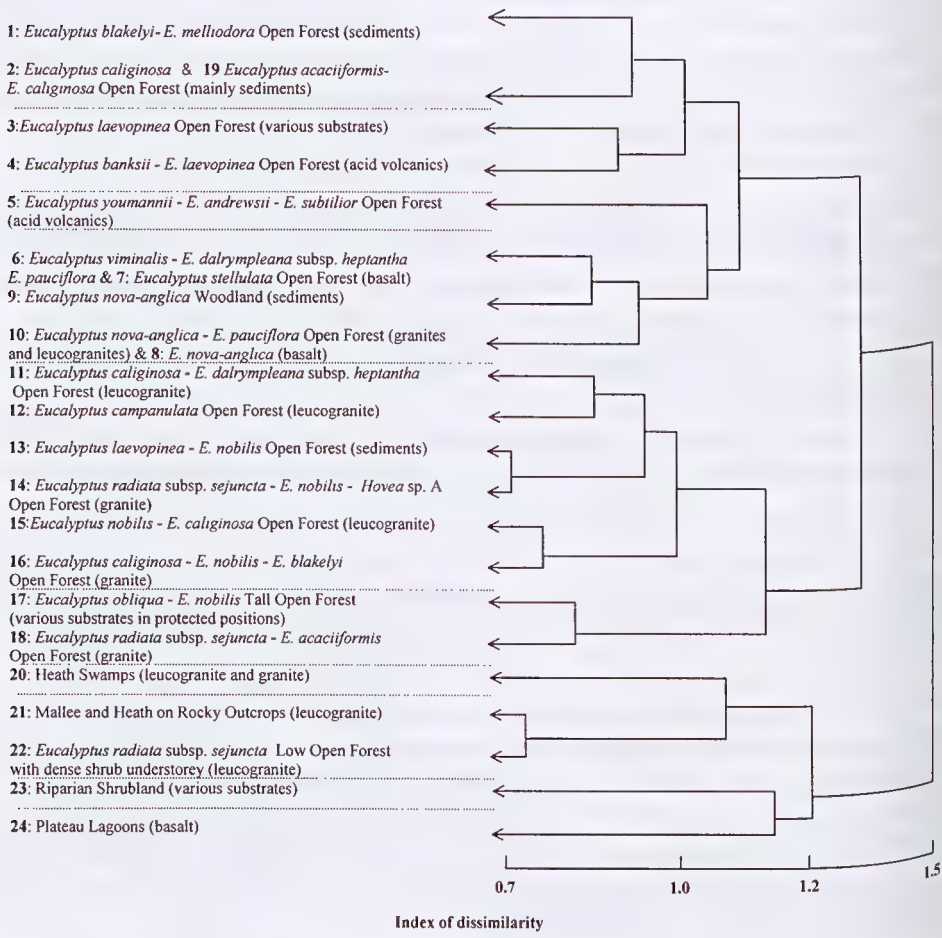

Fig. 5. Dendrogram showing the plant communities in 10 major groupings (divided by dotted lines) produced using Kulczynski association and flexible UPGMA fusion strategy and a ß value of -0.1 (see text for detailed descriptions of the communities).

5. Open forest principally on leucogranites and granites and mainly in the north-east of the study area dominated by Broad-leaved Stringybark (*Eucalyptus caliginosa*), New England Blackbutt (*Eucalyptus campanulata*), Mountain Gum (*Eucalyptus dalrympleana* subsp. *heptantha*) and Narrow-leaved Peppermint (*Eucalyptus radiata* subsp. *sejuncta*) (communities 11–16);

6. Tall open forest composed of Messmate (*Eucalyptus obliqua*), Forest Ribbon Gum (*Eucalyptus nobilis*) and open forest composed of Narrow-leaved Peppermint (*Eucalyptus radiata* subsp. *sejuncta*) and Wattle-leaved Peppermint (*Eucalyptus acaciiformis*), mainly on granites and leucogranites (communities 17–18);

7. Heath swamps on granites and leucogranites dominated by Sedges (Cyperaceae), Restionaceae and shrubs such as *Leptospermum gregarium*, *Banksia cunninghamii* subsp. A and *Epacris breviflora* (community 20);

8. Mallee Ash (*Eucalyptus codonocarpa*) with a dense heath-shrub understorey leucogranite on rocky outcrops, and Low Open Forest containing Broad-leaved Stringybark (*Eucalyptus caliginosa*) and Narrow-leaved Peppermint (*Eucalyptus radiata* subsp. *sejuncta*) with a tall dense shrub understorey composed of shrubs such as *Mirbelia confertiflora*, *Petrophile canescens* and *Leptospermum novae-angliae* on coarse sands on leucogranite (communities 21–22);

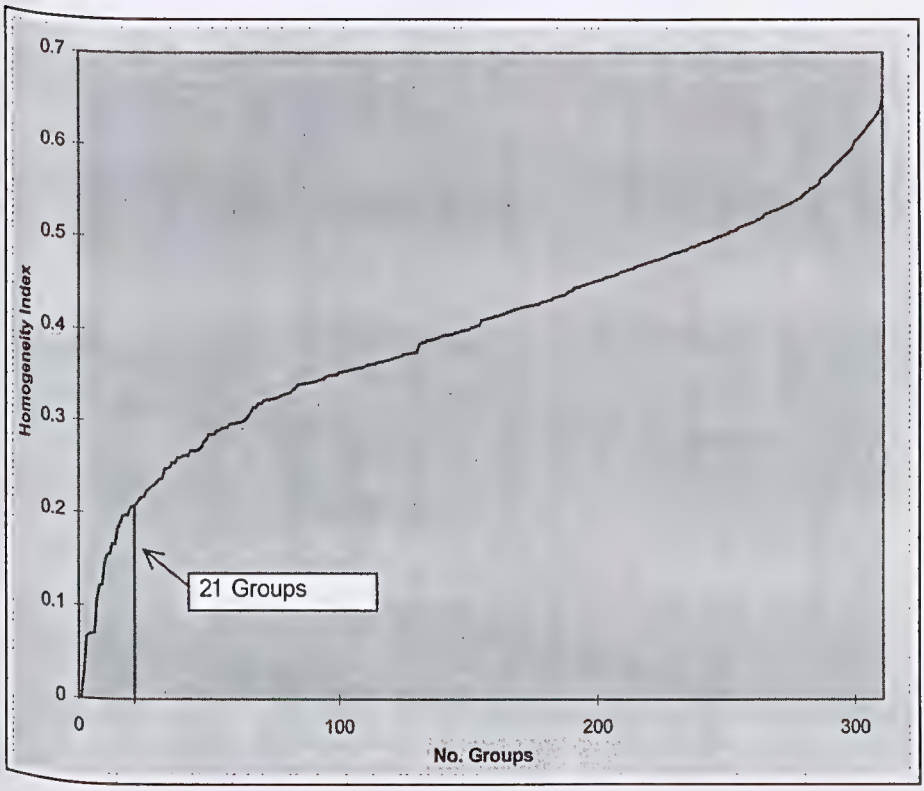

Fig. 6. Homogeneity of full floristic composition with increasing number of groups.

9. Riparian shrubland dominated by *Leptospermum polygalifolium* subsp. *transmontanum* on a number of substrates (community 23);

10. Water plants of the genera *Potamogeton*, *Myriophyllum*, *Eleocharis*, *Juncus*, and *Nymphoides* growing in open water in shallow lagoons on basalt (community 24).

Floristic composition

A total of 889 plant taxa in 118 families (18 families of pteridophytes, one family of gymnosperm and 99 families of angiosperms) have been recorded for the study area (Appendix 1). This represents 14% of the NSW flora. Only vascular plants were included in the survey.

A total of 681 taxa were recorded during the survey, the remaining 208 taxa were cited from herbaria collections and records supplied by local botanists. Of the total number of taxa, 743 were native and 146 (17%) were exotic being mainly pasture weeds. Families of angiosperms that contained 10 or more taxa are: Apiaceae (20); Asteraceae (97); Brassicaceae (10); Cyperaceae (43); Epacridaceae (18); Fabaceae (77); Juncaceae (20); Lamiaceae (10); Myrtaceae (41) (including 27 *Eucalyptus* species); Orchidaceae (44); Poaceae (135) (including 13 *Austrodanthonia*, 6 *Poa*, 8 *Eragrostis*, 7 *Aristida*, 10 *Austrostipa*, 7 *Deyeuxia*); Polygonaceae (12); Proteaceae (15); Rhamnaceae (10); Rubiaceae (14); Rutaceae (12); and Scrophulariaceae (19).

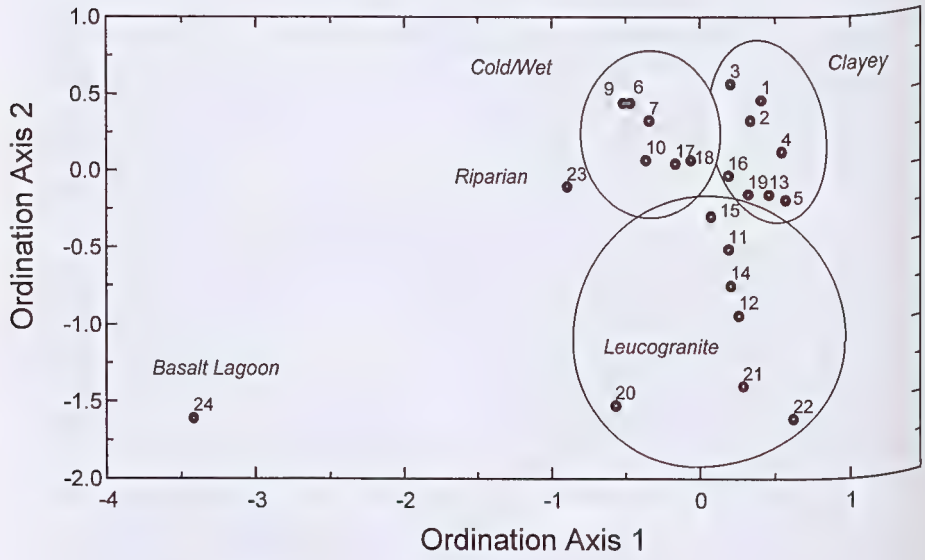

Fig. 7. Distribution of sites (centroids, labelled by plant community) in two-dimensional space. Five groups are evident in the ordination. Basalt Lagoon (24) and New England Riparian Shrubland (23) are highly distinct; communities 11, 12, 14, 15, 20, 21 & 22 occur on leucogranite; communities 1–5, 16 and 19 occur on clay soils derived from either sedimentary or acid volcanic substrate; and communities 6, 7, 9, 10, 17 & 18 experience cold temperature and/or high soil moisture at high altitudes or in valley bottoms.

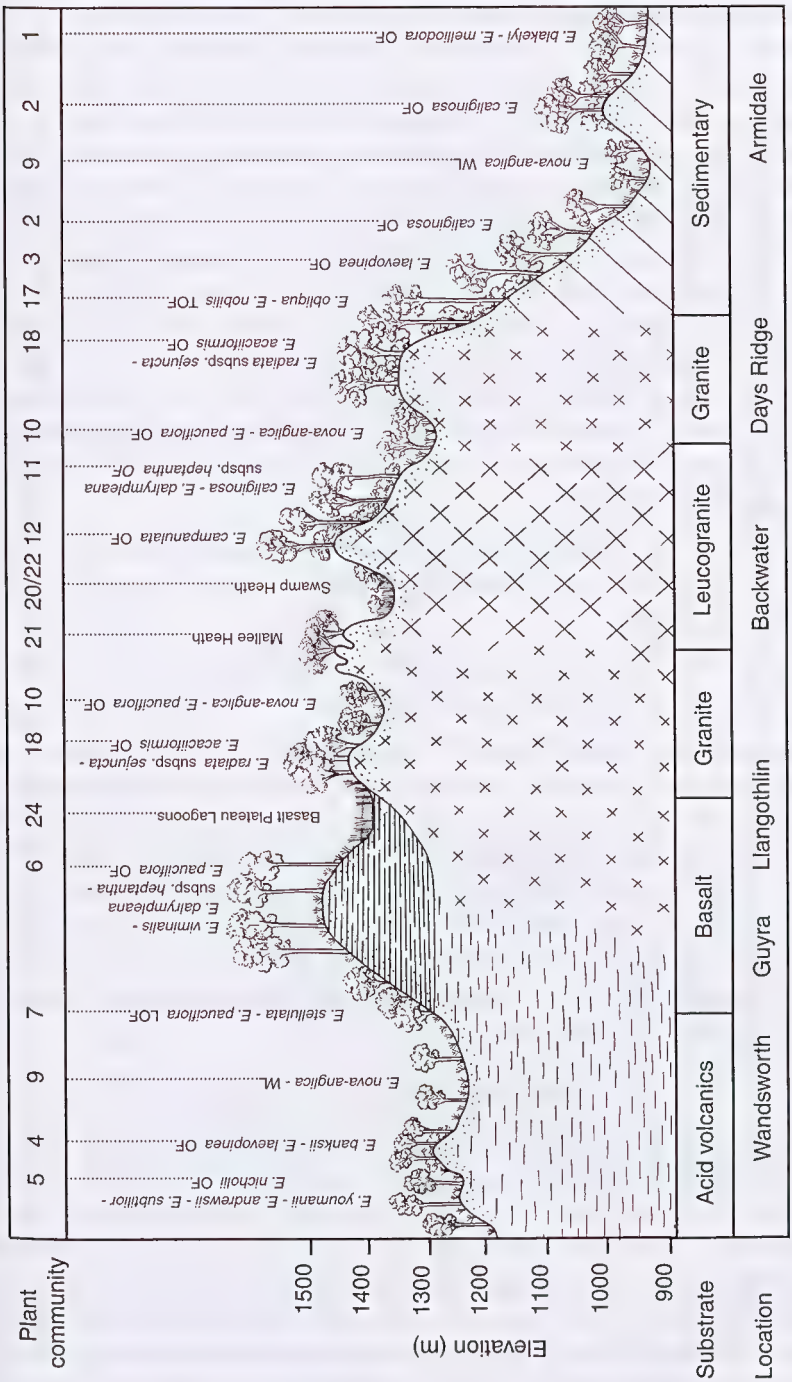

Fig. 8. Schematic transect of the landscapes present in the area covered by the Guyra 1: 100 000 map sheet showing the relationship between topographic position, elevation, substrate and plant communities. OF = Open-Forest, WL = Woodland, LOF = Low Open-Forest, TOF = Tall Open-Forest (after Walker & Hopkins 1990).

By examining Appendix 1 it can be seen that widespread (present in 75% of the communities) and commonly recorded taxa were: *Pteridium esculentum, Cheilanthes sieberi* subsp. *sieberi, Dichopogon fimbriatus, Hydrocotyle laxiflora, Brachyscome microcarpa, Senecio* sp. E, *Wahlenbergia stricta* subsp. *stricta, Scleranthus biflorus, Hypericum gramineum, Dichondra repens, Crassula sieberiana, Hibbertia linearis, Leucopogon lanceolatus* var. *lanceolatus, Melichrus urceolatus, Poranthera microphylla, Acacia dealbata, Acacia filicifolia, Desmodium varians, Hardenbergia violacea, Geranium solanderi* subsp. *solanderi, Gonocarpus tetragynus, Luzula densiflora, Ajuga australis, Lomandra longifolia, Lomandra multiflora* subsp. *multiflora, Eucalyptus caliginosa, Eucalyptus dalrympleana* subsp. *heptantha, Eucalyptus nobilis, Eucalyptus radiata* subsp. *sejuncta, Leptospermum polygalifolium* subsp. *transmontanum, Oxalis radicosa, Bursaria spinosa, Plantago gaudichaudii, Cymbopogon refractus, Austrodanthonia racemosa, Dichelachne micrantha, Echinopogon* spp., *Elymus scaber, Poa sieberiana, Austrostipa rudis* subsp. *nervosa, Themeda australis, Lomatia silaifolia, Ranunculus lappaceus, Acaena novae-zelandiae, Rubus parvifolius, Asperula conferta, Galium ciliare, Opercularia* spp., *Veronica calycina, Veronica plebeia* and *Viola betonicifolia.*

The most common weeds recorded were: *Hypochaeris radicata, Cirsium vulgare, Conyza albida, Taraxacum officinale, Trifolium repens, Anthoxanthum odoratum, Aira elegantissima* and *Rubus ulmifolius.*

Most species are sparsely distributed in the landscape and relatively few occur frequently across a number of plant communities.

Certain groups of plants tended to be more frequently recorded in some plant communities. For example, community 17, *Eucalyptus obliqua-Eucalyptus nobilis* contained more ferns than other communities. Communities 23 (riparian shrubland) and 24 (lagoons) contained more sedges (Cyperaceae) than other communities. More grasses were recorded in communities on higher nutrient soils, for example communities 1, 6, 7 and 9 than on low nutrient soils such as communities 11, 12, 20–22 which are restricted to leucogranite. This trend was reversed for species in the Proteaceae where more species from this family were recorded on the low nutrient soils compared to high nutrient soils.

Rare or threatened plant species

A total of 28 rare or threatened taxa has been recorded from the study area (Table 3) of which 10 were recorded in our survey. The remaining 18 species are from collections in the N.C.W. Beadle Herbarium of the University of New England, the National Herbarium of NSW, and various survey records. 25 of these taxa are listed in the national listing of rare or threatened Australian plant species (ROTAP) (Briggs and Leigh 1995). Nine of these taxa along with two other species, *Monotaxis macrophylla* and *Aldrovandra vesiculosa* (which are more common in other states but endangered in NSW), are listed in Schedules 1 or 2 of the NSW Threatened Species Conservation Act 1996. One unlisted species recorded in the survey, *Brachyloma saxicola*, could be considered nationally rare (Briggs and Leigh 1995) or Near Threatened using the criteria of IUCN (1999).

Table 3. List of rare or threatened plant species recorded from the Guyra 1: 100 000 map sheet area.

ROTAP code refers to Briggs and Leigh (1995). TSC Act refers to the threat category under the *NSW Threatened Species Conservation Act 1996*.

Species name	ROTAP Code	NSW TSC Act
Acacia brunioides subsp. *brunioides*	3RC-	Not listed
Aldrovandra vesiculosa	Not listed	Endangered
Asperula charophyton	3RCa	Not listed
Bothriochloa biloba	3V	Vulnerable
Brachyloma saxicola	Not listed (suggest 3RCa)	Not listed
Brasenia schreberi	3RC-	Not listed
Callitris oblonga subsp. *parva*	3VCa	Vulnerable
Cryptandra lanosiflora	3RCa	Not listed
Daviesia elliptica	3RC-	Not listed
Dichanthium setosum	3VC-	Vulnerable
Discaria pubescens	3RCa	Not listed
Eucalyptus camphora subsp. *relicta*	3VC-	Endangered
Eucalyptus codonocarpa	3RC-	Not listed
Eucalyptus michaeliana	3RCa	Not listed
Eucalyptus nicholii	3V (suggest 3VC-)	Vulnerable
Eucalyptus youmanii	2R (suggest remove)	Not listed
Euphrasia orthocheila	3RC-	Not listed
Goodenia macbarronii	3VC-	Vulnerable
Grevillea scortechinii subsp. *sarmentosa*	3VC-	Vulnerable
Monotaxis macrophylla	Not listed	Endangered
Muehlenbeckia costata	3KC-	Not listed
Persoonia procumbens	2RC-	Not listed
Leionema ambiens	3RC-	Not listed
Pseudanthus divaricatissimus	3RCa	Not listed
Pultenaea campbellii	3V (suggest R or remove)	Not listed
Thelionema grande	3RC-	Not listed
Thesium australe	3VCi (suggest R)	Vulnerable

Discussions of the rare or threatened taxa follow. Risk codes in capital letters are from Briggs and Leigh (1995) — consult this for an explanation of the codes. Codes in lower case refer to the taxon's listing under the NSW Threatened Species Conservation Act.

Acacia brunioides subsp. ***brunioides*** (Fabaceae) (3RC-): This shrub was recorded once in community 12 along the Sara River. This rare species is restricted to granite substrates in the New England Bioregion of NSW and Queensland.

Aldrovandra vesiculosa (Droseraceae) (e): This free floating aquatic herb was not recorded during the survey but has since been recorded in Llangothlin and Billy Bung Lagoons near Guyra (D. Bell pers. comm.). This species seems to appear and disappear in wetlands and has a low seed set. It is probably introduced by migratory waterbirds from time to time. It is a cosmopolitan species but it is likely the Australian entity is taxonomically distinct from the European one (S. Jacobs pers. comm.).

Asperula charophyton (Rubiaceae) (3RCa): This forb was recorded once during the survey on the edge of Mother of Ducks Lagoon in community 24 (basalt lagoon), near

the town of Guyra. It would appear to be very restricted in the study area but is recorded from the Warrumbungles National Park in the Nandewar Bioregion (north-western slopes).

Bothriochloa biloba (Poaceae) (3V) (v): This grass was once widespread and there are collections in the National Herbarium of NSW from western Sydney, the Hunter Valley, the Northern Tablelands and most commonly on the North Western Slopes near Inverell and Warialda. It has probably been reduced by grazing and cultivation and is not known to be conserved in a reserve. Recent surveys of the western slopes and plains indicate that the species may still be common in some places (Department of Land and Water Conservation pers. comm.). If so, the species may warrant removal from Schedule 2 of the TSC Act and down listing on ROTAP. While not recorded during the survey, there is a National Herbarium of NSW record collected from the New England Highway between Guyra and Armidale in 1955 by M. Gray.

Brachyloma saxicola (Epacridaceae): This shrub is restricted to seven areas of granitic outcrops on the Northern Tablelands (Hunter & Williams 1994). It was recorded a number of times in our survey on granitic rocky outcrops in the Backwater area (community 21). Hunter and Williams (1994) suggested this species should be coded 2VC under Briggs and Leigh (1995). This was revised by Richards and Hunter (1997) who suggested a ROTAP code of 3RCa. We consider it is not threatened and therefore should be coded as 3RCa under ROTAP and as Near Threatened under IUCN (1999).

Fig. 9. The threatened native conifer *Callitris oblonga* subsp. *parva* grows along several creeks in the study area and is susceptible to frequent fire.

Brasenia schreberi (Cabombaceae) (3RC-): This stoloniferous aquatic herb was not recorded during the survey, but has recently been collected from Llangothlin Lagoon (D. Bell pers. comm.). It occurs spasmodically in wetlands in eastern Australia and other parts of the world.

Callitris oblonga subsp. ***parva*** (Cupressaceae) (3VCa) (v): There are three subspecies of this taxon which is commonly known as Pigmy Cypress Pine: subsp. *oblonga* occurs in northern Tasmania, subsp. *corangensis* grows along the Corang River on the Southern Tablelands of NSW, and subsp. *parva* occurs in a number of locations on the Northern Tablelands of NSW. The distribution of the NSW locations of *Callitris oblonga* is documented in Nadolny and Benson (1993). In the study area, *Callitris oblonga* subsp. *parva* (Fig. 9) is restricted to leucogranite in the Backwater area, particularly along the Sara River, Stuttering Dicks Creek and Backwater Creek. It is mainly restricted to community 23 (riparian shrubland). The species is threatened by too-frequent fire and other disturbances along the watercourses where it grows.

Cryptandra lanosiflora (Rhamnaceae) (3RCa): This rare stunted shrub occurs on the Northern Tablelands and the tablelands of southern Queensland. J.T. Hunter collected this species in 1996 from leucogranite outcrops north of Backwater.

Daviesia elliptica (Fabaceae) (3RC-): This shrub was recorded once during the survey in community 10 adjacent to the Sara River near Mount Mitchell on leucogranite. This is the southern-most record for the species. It is very rare in the study area but National Herbarium of NSW collections reveal it is present on granite to the north in Boonoo Boonoo National Park, near the Timbarra River on the Glen Innes-Grafton Road and on the Darling Downs in Queensland. This species requires a targeted survey to establish its abundance and threat status.

Dichanthium setosum (Poaceae) (3VC-) (v): This grass is known from the Northern Tablelands, Western Slopes, North Western Plains and Queensland. National Herbarium of NSW records from the 1940s reveal that it grew along the Guyra-Ebor Road. The UNE herbarium has a record of this species from the original 'Saumarez' landholding, just south of Armidale. This grass would appear to be rare and requires specific surveys to establish its status.

Discaria pubescens (Rhamnaceae) (3RCa): This widespread rare shrub occurs along the tablelands of NSW in areas that have been protected from intense grazing. It was not recorded during the survey, but herbarium records reveal it has been collected from the Paddys Gully area near Backwater, Oban River, near Boorolong and near Guyra during the period 1967–1989. It was also recorded in Little Llangothlin Nature Reserve in 1994 (D. Bell pers. comm.).

Diuris pedunculata (Orchidaceae) (2E) (e): This ground orchid is probably the most endangered plant species in the study area and one of the rarest on the Northern Tablelands in general. It was not recorded during the survey but there is a herbarium record from 'Hardacres' near Boorolong (UNE herbarium database) and several records from the 1930s and 1940s by McKie for 'just south of Guyra'. Over the last decade the species has been found on the railway easement near Armidale (but could not be re-located there in 1994, Metcalfe pers. comm.), adjacent to the New England

Fig. 10. The mallee, *Eucalyptus codonocarpa*, is listed as a rare species nationally. It occurs on rocky leucogranite outcrops near Backwater.

highway south of Uralla, near the Ebor Trout Hatchery and near 'Sandy Creek' on a travelling stock reserve (TSR) on the Guyra-Inverell Road north-west of Guyra. It would appear this is a critically endangered species requiring special research and conservation effort.

Eucalyptus camphora subsp. ***relicta*** (Myrtaceae) (3VC-) (e): A small population of this species occurs in the northern edge of the Guyra map sheet overlapping onto the Glen Innes map sheet to the north. Its only population in the study area is in a heath-swamp (community 20) along a creek on the eastern side of Crown Mountain in Warra National Park (formerly state forest). There are only a few other localities for this taxon and it is correctly ranked as an endangered subspecies in NSW.

Eucalyptus codonocarpa (Myrtaceae) (3RC-): This mallee-eucalypt is restricted to granite outcrops on the Northern Tablelands and is found in Gibraltar Range, Cathedral Rock and Girraween National Parks. In the study area it was confined to community 21 on leucogranite outcrops north of Backwater (Fig. 10). If some of the leucogranite country at Backwater was protected in reserves, this species should then be considered adequately reserved ie 3RCa.

Eucalyptus michaeliana (Myrtaceae) (3RCa): This species is most common on the escarpment of the Macleay gorges to the south-east of the study area (NSW NPWS 1985). There is a single University of New England record of this species in the study area, at Brookside along the Rockvale Road. Despite searching for it in this area the species was not recorded during the survey.

Eucalyptus nicholii (Myrtaceae) (3V) (v): This species was recorded only in community 5. It occurs mainly on acid volcanic substrates in the north-western section of the study area and is more common further west near Tingha. Most of its habitat has been cleared and little is protected in reserves, although the proposed Moredun Creek Nature Reserve to the west of the map sheet, if declared, would protect a stand of this species. The recent dedication of Single State Forest as a national park protects a stand of *Eucalyptus nicholii* west of the study area.

Eucalyptus youmanii (Myrtaceae) (2R): This stringybark was recorded in community 1 and in community 5. Most of its habitat has been cleared and it is poorly represented in reserves. It is not as rare as previously thought and should be removed from ROTAP. However, it is not as widespread as other stringybark species on the Northern Tablelands.

Euphrasia orthocheila (Scrophulariaceae) (3RC-): There is one specimen in the National Herbarium of NSW from the study area 12 km east of Guyra collected by J. Boorman in 1917. It was not recorded during the survey. It has been recorded in Girraween and Mount Kaputar National Parks.

Fig. 11. *Grevillea scortechinii* subsp. *sarmentosa* is listed as vulnerable species nationally. It is restricted to the leucogranite outcrops northeast of Backwater in the study area.

Goodenia macbarronii (Goodeniaceae) (3VC-) (v): This forb was not recorded during the survey, but two old specimens from the area are held in the National Herbarium of NSW. One from Chandlers Peak near Guyra was collected by Boorman in 1917, and another from Moredun Creek, collected by E. McKie in 1948. Most collections of this species are from the Pilliga Scrub region on the North Western Slopes. This species may be extinct on the Northern Tablelands.

Grevillea scortechinii subsp. ***sarmentosa*** (Proteaceae) (3VC-) (v) (Fig. 11): This decumbent shrub is restricted to a few granite outcrops on the Northern Tablelands. It was recorded in communities 11, 12, 19, 22, and 23. It was found to be locally common in forests on the leucogranite outcrop north of Backwater. If some of its populations were protected for conservation in this area this species should be down-listed to the rare category in ROTAP and/or Near Threatened in IUCN (1999). It should be removed from Schedule 2 (vulnerable) of the TSC Act.

Monotaxis macrophylla (Euphorbiaceae) (e): Collected once in the area by J.T. Hunter. This is a new record for the Northern Tablelands where it was located growing in post-fire regrowth on leucogranite near Backwater. In the National Herbarium, there are specimens collected in 1904 from the North-western Slopes and North-western Plains and in 1991 from the South Coast. This species appears to be very rare and may require certain fire regimes to persist.

Muehlenbeckia costata (Polygonaceae) (3KC-): This decumbent scrambler occurs on and between rocky outcrops in Warra National Park (J.T. Hunter pers. comm.). This species is a fire ephemeral and germinates prolifically after fire but then dies back soon afterwards (Hunter et al. 1998). It has also been recorded in Bald Rock and Girraween National Parks to the north and Butterleaf State Forest to the east of the study area. Given its rarity and dependence on certain fire regimes, it should be listed as a vulnerable species under both ROTAP and the TSC Act.

Persoonia procumbens (Proteaceae) (2RC-): This low growing shrub has a similar distribution to *Grevillea scortechinii* subsp. *sarmentosa* in that it grows on granite substrates on the Northern Tablelands. It was recorded in communities 11, 12 and 14. It occurs in Warra National Park, but its largest populations in the study area are on private land near Backwater.

Leionema ambiens (Rutaceae) (3RC-): This shrub is restricted to some of the rocky outcrops in the Warra National Park and also occurs near Backwater in community 21. It has been collected in the northern part of the Northern Tablelands at Bald Rock, Timbarra, Tenterfield and Bismuth and occurs in Queensland.

Pseudanthus divaricatissimus (Euphorbiaceae) (3RCa): This prostrate shrub occurs in small populations from East Gippsland along the Great Dividing Range to Queensland. It has been collected by J.T. Hunter from the leucogranite in the study area.

Pultenaea campbellii (Fabaceae) (3V): This shrub is mainly located on acid volcanic substrates in the north-western section of the study area. It has been recorded in communities 1, 2 and 5. This species is not vulnerable and could be removed from ROTAP. It has recently been removed from schedule 2 of the NSW TSC Act.

Thelionema grande (Phormiaceae) (3RC-): This tufted herb has been found on sandy soils derived from granites. It occurs on the New England Tablelands in southern Queensland and NSW. In NSW this species has been collected at Boonoo Boonoo, Tenterfield and Torrington. J.T. Hunter collected it in the mid-1990s on leucogranite near Backwater.

Thesium australe (Santalaceae) (3VCi) (v): A widespread semi-parasitic forb occurring from Victoria to Queensland. It has probably been reduced in abundance due to grazing (Archer 1984). In NSW it is conserved in a number of north coast reserves and Kosciuszko National Park, and Namadgi National Park in the ACT. It was recorded in community 6 on basalt and in community 18 on granite. Most of these sites are in strips of roadside vegetation. It is usually found with the grass *Themeda australis* which it parasitises (Griffith 1992). Other populations in the study area have recently been documented by the University of New England including several in Little Llangothlin Nature Reserve (D. Bell pers. comm.). It would appear that this rather cryptic forb may be more common than previously thought and could be considered rare rather than vulnerable. Its conservation would be enhanced if protection could be afforded to some of its known populations near Guyra.

Regionally rare species

Using the results of the survey and herbaria data, it would appear that a number of plant species could be considered rare in the context of the study area, although many of these are known to be more common elsewhere. The following list includes some of the species that were recorded once during the survey, and/or species that have been rarely collected in the past, but known from herbaria collections from the area. Plants were excluded from the list if they are known to respond to seasonal conditions or occur in habitats that have not been thoroughly surveyed. These include most of the grasses, geophytes such as orchids, various families of water plants, and most of the sedges (Cyperaceae) and rushes (Juncaceae).

After applying this filter, species deemed to be regionally rare in the area covered by the Guyra 1: 100 000 map sheet are:

- the ferns *Blechnum minus* and *Botrychium australe;*
- the forbs *Eryngium ovinum, Hydrocotyle peduncularis, Caesia parviflora, Burmannia disticha, Centrolepis strigosa, Atriplex semibaccata, Chenopodium carinatum, Swainsona monticola, Swainsona oroboides, Centaurium spicatum, Geranium retrorsum, Goodenia gracilis, Velleia paradoxa* and *Plantago varia;*
- the sedges *Baumea nuda* and *Caustis pentandra;*
- the daisies *Lagenifera gracilis, Microseris lanceolata, Olearia alpicola, Olearia cydoniifolia, Olearia rosmarinifolia, Podolepis jaceoides, Podolepis neglecta, Pseudognaphalium luteoalbum, Senecio bipinnatisectus, Senecio gunnii, Stuartina muelleri, Vittadinia dissecta* var. *hirta;*
- the shrubs *Acacia leucolobia* (extension of range), *Daviesia acicularis, Bossiaea prostrata, Dillwynia juniperina, Pultenaea myrtoides, Sphaerolobium minus, Prostanthera nivea, Persoonia oleoides, Pomaderris andromedifolia, Pomaderris eriocephala, Boronia microphylla, Santalum obtusifolium, Zieria laevigata, Tasmannia stipitata;*

- the grass, *Poa clivicola* was recorded once at site 235 in New England Peppermint regrowth, a northern extension of its range. A northern form of *Poa costiniana* was recorded at a number of sites, mainly in community 6 on basalt.

Description of plant communities

Approximately 69 000 ha or 26% of the Guyra 1: 100 000 map sheet area was mapped as native vegetation using aerial photographic interpretation. However, as mentioned previously, we did not map native grasslands or patches of vegetation less than one hectare in size.

The 24 mapped plant communities are described below, complemented by a photograph of each community. Some are more homogeneous in their floristic composition than others. Some are widely distributed, for example communities 2, 3, 17 and 23. Others are geographically restricted, for example communities 13, 14, 20, 21 and 24. The fidelity analysis (Bedward unpublished software) revealed that the ubiquitous stringybark plant communities 2 and 3 contain one and no indicator species respectively. Most species in them are common across the landscape. In contrast, communities 24 (swamps on basalt) and 21 (rocky outcrops on leucogranite) contain a large number of indicator species that are restricted to those communities.

The 24 plant communities are described using dominant canopy species as the main descriptor. Codes from previous forest classifications that best match the plant communities are listed. The relevant previous classifications referred to are the forest plant communities of Hager and Benson (1994) and the forest types of Forestry Commission of New South Wales (1989). Generally, forest types are much broader in their definition than Hager and Benson (1994) or the classification derived in this survey.

Sites classified into each community are listed. Information on location, physical features and floristics for each sample site is held by the Royal Botanic Gardens. The structural classification follows Walker and Hopkins (1990). The mean number of species recorded in the 20 × 20 m plots per community is given. Indicator species were those species that occurred in > 50% of the sites in a community and had a high fidelity to that group (> 0.8 derived from the fidelity analysis, Bedward unpublished software). The frequency of occurrence of each species in each community is shown in Appendix 1.

A threat status code for the plant communities in the study area have been derived by comparing the area of extant vegetation with an estimate of the pre-European extent (see thresholds in methods section and Table 4). The reservation code is based on percentage protected in reserves compared to an estimate of pre-European extent. The threat and reservation codes given for New South Wales are estimates only based on the authors' knowledge of the distribution and abundance of each plant community over its geographical range.

Community 1: Blakely's Red Gum (*Eucalyptus blakelyi*)-Yellow Box (*Eucalyptus melliodora*) Open Forest (Fig. 12)

Equivalent in Hager and Benson (1994): EF712b&c, EF446c; **Forest Type:** 172, 177

Sample sites (23): 1, 2, 29, 69, 74, 76, 77, 78, 82, 84, 113, 159, 217, 219, 220, 223, 225, 227, 250, 282, 283, 284, 303

Landform: Mainly flats and lower slopes adjoining valleys, occasionally ridges

Substrate: Fine-grained sedimentary rocks such as shale, mudstone and medium nutrient volcanics

Soils: Grey, red or brown clay podsolics

Elevation: 980–1200 m

Distribution: Mainly in the south near Armidale, Old Armidale Road, Boorolong Road, Devils Pinch, Gara River valley and near Thalgarrah

Extant area: native understorey: 4847 ha; exotic understorey: 1765 ha; **Total:** 6612 ha

Estimated remaining extent of pre-European extent: 20%

Structure: Open forest with trees between 12 and 20m with a mid-dense (30–50%) crown cover; shrubs sparse with a mid-dense ground cover

No. native species: 185; **Mean no. per site:** 33 +/- 8.9

No. exotic species: 38; **Mean no. per site:** 5.9 +/- 4.6

Indicator native species: *Eucalyptus blakelyi, Eucalyptus melliodora, Bothriochloa macra*

Common native species:

- Trees: *Eucalyptus blakelyi, Eucalyptus melliodora* with either *Eucalyptus caliginosa, Eucalyptus laevopinea* or *Eucalyptus youmanii*
- Shrubs: *Acacia implexa, Bursaria spinosa, Lissanthe strigosa, Hibbertia linearis, Opercularia aspera, Pimealea curviflora* var. *divergens, Rubus parvifolius*
- Ground cover: *Poa sieberiana, Dichondra repens, Geranium solanderi* var. *solanderi* , *Desmodium varians, Bothriochloa macra, Asperula conferta, Acaena ovina, Themeda australis, Sclerolaena biflorus, Wahlenbergia planifolia* subsp. *planifolia, Austrodanthonia* species

Common exotic species: *Hypochaeris radicata, Rosa rubiginosa, Plantago lanceolata, Paronychia brasiliana, Vulpia myuros, Trifolium* species

Variability: This community includes a small stand of *Eucalyptus moluccana* on Rockvale Road. The stringybark, *Eucalyptus youmanii*, is occasionally

Fig. 12. Community 1 *Eucalyptus blakelyi-Eucalyptus melliodora* open forest on fine-grained sedimentary substrate on a travelling stock reserve near Boorolong west of Armidale.

present. Stringybarks are often common in this community and this community often merges with community 2. Understorey varies depending on grazing pressure and aspect, but contains a suite of grasses, forbs and shrubs.

Condition: Most of the original extent has been cleared, although regrowth occurs in some areas and remnants occur along roadsides and in travelling stock routes. Remnants on private land generally contain a highly modified understorey due to continuous grazing.

Threats: As this community occurs on medium nutrient soils, areas are still prone to clearing. Dieback killed many trees in the 1970s and remains a threat. Understorey of most remnants on private land has been altered by grazing. Exotic pasture species have been sown or have invaded many places.

Threat status: Guyra: E(i), **NSW:** E(i)

Reservation code: Guyra: VP, **NSW:** VP

No. reserves in study area containing this community: 1; **Area reserved:** 1 ha

Conservation status: Small remnants occur on roadsides and on private land, only one hectare is protected in reserves. Reduced to about 20% of its original extent.

Key sites for conservation: Site 84, Rockvale Road TSR near Chandlers Road which has a low grazing pressure and a tablelands occurrence of *Eucalyptus moluccana*. Site 223 roadside on Old Armidale Road. Site 82 adjoining Thalgarrah Field Studies Centre. Site 113, Devils Pinch which contains *Eucalyptus youmanii* in a Crown reserve.

Community 2: Broad-leaved Stringybark (*Eucalyptus caliginosa*) Open Forest (Fig. 13)

Equivalent in Hager and Benson (1994): EF481a,b,c; **Forest Type:** 122

Sample sites (40)**:** 23, 25, 26, 66, 68, 70, 73, 81, 83, 85, 86, 87, 88, 89, 91, 92, 99, 102, 106, 108, 109, 157, 158, 175, 189, 203, 207, 209, 213, 231, 238, 239, 240, 269, 291, 292, 302, 307, 308, 309

Landform, substrate and soils: Mainly confined to ridges and upper slopes on siliceous sedimentary rocks (greywacke), granite and acid volcanics with brown, sandy clay soils.

Distribution: Widely scattered over southern and western sections of the study area. Absent from the granites and leucogranites in the north-east, although *Eucalyptus caliginosa* itself is common as a co-dominant tree in other plant communities on these geologies. It is the most common plant community in the study area.

Fig. 13. Community 2, *Eucalyptus caliginosa* open forest is widespread and usually occurs on ridges composed of siliceous sediments. This shows site 68 just east of Armidale, composed of regrowth with a heavily grazed understorey.

Extant area: native understorey: 9844 ha; exotic understorey: 1302 ha; **Total:** 11 146 ha

Estimated remaining extent of pre-European extent: 60% (mainly regrowth)

Structure: Open forest, trees 15–25 m high with a mid-dense (30–50%) crown cover, some regrowth areas have a dense (50–80%) crown cover. Shrubs sparse, ground cover sparse, to mid-dense

No. native species: 212; **Mean no. per site:** 30 +/- 7

No. exotic species: 41; **Mean no. per site:** 7 +/- 4

Common native species:

- Trees: *Eucalyptus caliginosa* with either *Eucalyptus melliodora*, *Eucalyptus blakelyi*, *Eucalyptus bridgesiana*, *Eucalyptus viminalis*
- Shrubs: *Lissanthe strigosa*, *Melichrus urceolatus*, *Hibbertia linearis*, *Acacia implexa*
- Ground cover: *Geranium solanderi* var. *solanderi*, *Dichondra repens*, *Poa sieberiana*, *Glycine clandestina*, *Scleranthus biflorus*, *Poranthera microphylla*, *Rumex brownii*, *Veronica calycina*, *Hypericum gramineum*

Indicator native species: *Eucalyptus caliginosa*

Common exotic species: *Hypochaeris radicata*, *Trifolium repens*, *Paronychia brasiliana*, *Taraxacum officinale*, *Rosa rubiginosa*

Variability: Very variable with low species fidelity compared to some other communities. The closely related community 19 occurs along Rockvale Road north-east of Armidale and is dominated by *Eucalyptus acaciiformis*.

Condition: Extensively cleared and now mainly regrowth. Understorey often heavily grazed but the stringybark trees are less affected by dieback than other tree species. Some fenced off areas have denser shrub layers.

Threats: Due to this community occurring on ridges and poorer soils, it is less threatened than valley communities and many areas have regrown after clearing in the early 20th century.

Threat status: Guyra: LC (i); **NSW:** LC(i)

Reservation code: Guyra: P; **NSW:** M

No. reserves in study area containing this community: 2; **Area reserved:** 443 ha

Conservation status: Represented in Mount Duval and Boorolong Nature Reserves.

Key sites for conservation: Site 92 roadside reserve on Eastview Road, site 95 along Rockvale Road near 'Tarrangower', site 309 'Caer Timvil' off New England Highway, site 175 Wandsworth Road near 'Glen Park', site 213 Little Mount Duval.

Community 3: Silver-top Stringybark (*Eucalyptus laevopinea*) Open Forest (Fig. 14)

Equivalent in Hager and Benson (1994): EF479a,c; **Forest Type:** 167

Sample sites (41): 28, 71, 72, 75, 79, 90, 94, 104, 105, 111, 112, 114, 161, 176, 188, 190, 195, 196, 197, 198, 199, 200, 201, 202, 204, 205, 206, 208, 224, 226, 228, 229, 230, 237, 248, 249, 285, 286, 294, 301, 304

Landform, substrate and soils: Often occurs on steep escarpment slopes and often on rich soils such as those derived from basalt — but also occurs on sedimentary, acid volcanic and granitic substrates. At elevations 970–1300 m.

Distribution: Widespread on different substrates from near Armidale and Mount Duval in the south-west, Black Mountain to Ben Lomond in the central-west and Lagune Sugarloaf in the east.

Structure: Open forest with trees 12–25 m high, generally mid-dense (30–50%) crown cover but more dense in some regrowth stands. Sparse to mid-dense shrub layer (10–50% cover); mid-dense to dense ground cover (30–80 %) cover.

Extant area: native understorey: 9000 ha; exotic understorey: 1084 ha; **Total:** 10 084 ha

Estimated remaining extent of pre-European extent: 50% (much is regrowth)

No. native species: 205; **Mean no. per site:** 32 +/- 8

No. exotic species: 50; **Mean no. per site:** 6 +/- 4

Common native species:

- Trees: *Eucalyptus laevopinea* commonly with *Eucalyptus melliodora*, *Eucalyptus bridgesiana*, *Eucalyptus dalrympleana* subsp. *heptantha*, *Angophora floribunda*
- Shrubs: *Bursaria spinosa*, *Lissanthe strigosa*, *Acacia dealbata*, *Hibbertia linearis*
- Ground cover: *Poa sieberiana*, *Dichondra repens*, *Glycine clandestina*, *Veronica calycina*, *Desmodium varians*, *Geranium solanderi* var. *solanderi*, *Acaena novae-zelandiae*, *Hydrocotyle laxiflora*, *Elymus scaber*

Indicator native species: The fidelity analysis did not identify any indicator species for this community reflecting that it contains species that commonly occur in other communities.

Fig. 14. Community 3, *Eucalyptus laevopinea* open forest is common on slopes and ridges composed of fine-grained sedimentary, basalt or acid volcanic rocks. Trees are over 20 m high at site 105 shown here in Boorolong Nature Reserve.

Common exotic species: *Hypochaeris radicata, Vulpia myuros, Taraxacum officinale, Paronychia brasiliana, Cirsium vulgare*

Variability: A number of subgroups are geographically based, for example, the sites on Mount Duval are floristically similar to each other.

Condition: Mostly cleared. Most remnants are 50 year + regrowth. The understorey is generally in poor condition except in areas protected from excessive grazing–for example Mount Duval.

Threats: Clearing (including ringbarking) threatens areas on better soils such as basalt, although in some places trees are regrowing from past clearing, particularly on steep slopes. The understorey of most remnants on private land is degraded due to heavy grazing.

Threat status: Guyra: NT(i), **NSW** NT(i)

Reservation code: Guyra: P, **NSW:** P

No. reserves in study area containing this community: 2; **Area reserved:** 373 ha

Conservation status: This community is inadequately reserved, but is represented in the newly dedicated Mount Duval and Boorolong Nature Reserves, and is on Crown land at Devils Pinch.

Key sites for conservation: Crown land at Thunderbolts Cave near Devils Pinch (site 28).

Community 4: Tenterfield Woollybutt *(Eucalyptus banksii)*-Silver-top Stringybark *(Eucalyptus laevopinea)* Open Forest (Fig. 15)

Equivalent in Hager and Benson (1994): EF507c; **Forest Type:** nil

Sample sites (8)**:** 80, 103, 110, 297, 299, 300, 305, 306

Landform, substrate and soils: Steep, rocky upper slopes or ridges on acid volcanic or sedimentary substrates with grey clay soils. At elevations 1140–1270 m.

Distribution: Restricted to a few locations. In the south-western part of the study area it occurs in the Devils Pinch-Black Mountain region. Present on Little Duval, and on higher peaks of Boorolong Nature Reserve. Most common on the acid volcanic substrate of the western part of the study area, for example near Abington Creek.

Extant area: native understorey: 328 ha; exotic understorey: 9 ha; **Total:** 337 ha

Estimated remaining extent of pre-European extent: 70%

Structure: Trees 10–20 m high, with a mid-dense to dense (30–80%) crown cover; sparse or no shrub layer; sparse to mid-dense ground cover.

No. native species: 87; **Mean no. per site:** 30 +/- 10

No. exotic species: 17; **Mean no. per site:** 2 +/- 1

Common native species:

- Trees: *Eucalyptus banksii*, *Eucalyptus laevopinea*
- Shrubs: *Olearia viscidula*, *Opercularia aspera*, *Hibbertia linearis*, *Lissanthe strigosa*
- Ground cover: *Poa sieberiana*, *Poranthera microphylla*, *Lomandra filiformis* subsp. *coriacea*, *Dichelachne micrantha*. *Joycea pallida* formed a dense grass cover at two sites.

Indicator native species: *Eucalyptus banksii*, *Eucalyptus laevopinea*, *Olearia viscidula*, *Lomandra filiformis* subsp. *coriacea*

Common exotic species: *Hypochaeris radicata*

Variability: Little variation. Some understorey differences between sites such as the presence of *Joycea pallida*.

Condition: Relatively good, few weeds, due to its location on siliceous substrates and rocky ground. Fenced-off areas have a more dense understorey than areas subjected to grazing by stock.

Threats: Main threats are grazing of the understorey and cutting trees for firewood.

Threat status: Guyra: NT(ii); **NSW:** NT(ii)

Reservation code: Guyra: P; **NSW:** M

No. reserves in study area containing this community: 1; **Area reserved:** 13 ha

Reservation status: Poorly conserved — a small patch is reserved in Boorolong Nature Reserve.

Fig. 15. Community 4, *Eucalyptus banksii-Eucalyptus laevopinea* mainly occurs on upper slopes on acid volcanic rocks. It also occurs on siliceous sedimentary rocks such as this stand at site 110 on an escarpment 20 km north of Armidale.

Key sites for conservation: Site 80 on Sunnyside Road where the tufted grass *Joycea pallida* dominates the ground layer. Also sites 299 and 306 on acid volcanic substrate in the Abington Creek region.

Community 5: Youman's Stringybark (*Eucalyptus youmanii*)-Western New England Blackbutt (*Eucalyptus andrewsii*)-*Eucalyptus subtilior* +/- Narrow-leaved Black Peppermint (*Eucalyptus nicholii*) Open Forest (Fig. 16)

Equivalent in Hager and Benson (1994): EF486a; **Forest Type:** 122

Sample sites (17)**:** 8, 9, 12, 13, 14, 160, 177, 178, 179, 215, 221, 287, 288, 289, 290, 295, 298

Landform, substrate and soils: Ridges and slopes on acid volcanic substrates with yellow-brown clays.

Distribution: North-west of Guyra including Happy Valley, Wandsworth Road, Whans Road, Elderberry Creek at elevations 1110–1320 m.

Extant area: native understorey: 3154 ha; exotic understorey: 176 ha; **Total:** 3330 ha

Estimated remaining extent of pre-European extent: 15%

Structure: Open forest with trees 12–18 m high and with a mid-dense to dense (30–80%) crown cover, very sparse shrub layer and sparse ground cover.

No. native species: 173; **Mean no. per site:** 31 +/- 9

No. exotic species: 29; **Mean no. per site:** 4 +/- 5

Common native species:

- Trees: *Eucalyptus andrewsii, Eucalyptus youmanii, Eucalyptus subtilior, Eucalyptus caliginosa, Eucalyptus dalrympleana* subsp. *heptantha, Eucalyptus nicholii,* with a subgroup containing *Eucalyptus prava* on ridges in one area
- Shrubs: *Melichrus urceolatus, Hibbertia linearis, Hovea linearis, Pultenaea campbellii*
- Ground cover: *Poranthera microphylla, Oxalis radicosa, Hardenbergia violacea, Gonocarpus tetragynus, Dichondra repens, Dichelachne micrantha, Poa sieberiana, Goodenia hederacea* subsp. *hederacea*

Indicator native species: *Eucalyptus andrewsii, Goodenia bellidifolia* subsp. *bellidifolia, Oxalis radicosa*

Common exotic species: *Hypochaeris radicata, Aira elegantissima, Trifolium repens*

Variability: This community is defined by its understorey. The sites are pulled together in the floristic analysis due mainly to the sharing of common understorey species growing on acid volcanic soils in the drier, western part of the study area. There is considerable variation in tree species

Fig. 16. Community 5, at site 14 adjacent to the Guyra-Tingha Road containing *Eucalyptus subtilior, Eucalyptus andrewsii* and *Eucalyptus caliginosa* on acid volcanic rock.

depending on the landform position (high slope to lower slopes). For example, *Eucalyptus nicholii*, *Eucalyptus youmanii* and *Eucalyptus dalrympleana* subsp. *heptantha* tend to grow on lower slopes or flatter terrain (most of which has been cleared). In contrast, *Eucalyptus prava* and *Eucalyptus andrewsii* occur on shallow soils on rocky steeper-sloped terrain (much of which remains uncleared). It is likely that further sampling to the west of the study area would yield data that would warrant splitting this community.

Condition: Lower slopes mainly cleared, large remnants on rocky ridges persist.

Threats: Most of the occurrences of this community on lower slopes or flat terrain have been cleared for grazing. Subdivision and hobby farms threaten larger remnants in rocky terrain. Heavy grazing of remnant understorey and firewood cutting are the main threats.

Threat status: Guyra E(i); **NSW:** E(i)

Reservation code: Guyra VP; **NSW:** P

No. reserves in study area containing this community: 0; **Area reserved:** 0

Reservation status: The recent dedication of Single State Forest as Single Nature Reserve to the west of the study area protects a sample of this threatened plant community. Parts of Kings Plains National Park and Torrington State Recreation Area sample vegetation that is similar. This community is not protected in reserves in the study area.

Key sites for conservation: A number of sites are important due to degree of clearing of the community and the presence of the rare species (*Eucalyptus nicholii*): Sites 12 and 13 along Wandsworth Road, site 14 TSR on Tingha Road north of Wandsworth, sites 288, 289 and 290 near Reedy Creek, site 215 Fleetwood Road west of Boorolong, site 178 Happy Valley.

Community 6: Ribbon Gum (*Eucalyptus viminalis*)-Mountain Gum (*Eucalyptus dalrympleana* subsp. *heptantha*)-Snow Gum (*Eucalyptus pauciflora*) Open Forest-Tall Open Forest with a Grassy Understorey on Basalt (Fig. 17)

Equivalent in Hager and Benson (1994): EF415b; **Forest Type:** 159

Sample sites (17): 6, 7, 10, 11, 30, 31, 46, 155, 156, 180, 181, 182, 185, 186, 187, 253, 310

Landform, substrate and soils: Mainly confined to the high undulating, basalt plateau centred on Guyra with deep, chocolate or krasnozem loam soils. Numerous swampy depressions are present on the plateau.

Distribution: Extending along the spine of the Great Dividing Range at high elevations (1200–1500 m), from Ben Lomond in the north to Black Mountain in the south. Outlying occurrences occur on Mount Mitchell in the north-east and near Armidale in the south.

Extant area: native understorey: 3119 ha; exotic understorey: 3524 ha; **Total:** 6643 ha

Estimated remaining extent of pre-European extent: 15%

Structure: Open forest to tall open forest. Trees mainly about 20 m high but up to 30 m. Mid-dense cover (30–50%); shrub layer is very sparse (10%) and ground cover is dense or very dense (50–100%) and dominated by grass species.

No. native species: 155; **Mean no. per site:** 32.9 +/- 9

No. exotic species: 50; **Mean no. per site:** 10 +/- 5.2

Common native species:

- Trees: *Eucalyptus viminalis*, *Eucalyptus dalrympleana* subsp. *heptantha*, *Eucalyptus pauciflora* occasionally *Eucalyptus stellulata*
- Shrubs: *Acacia dealbata*, *Pultenaea microphylla*, *Pimelea linifolia*
- Ground cover: *Geranium solanderi* var. *solanderi*, *Hydrocotyle laxiflora*, *Glycine clandestina*, *Rubus parvifolius*, *Asperula conferta*, *Themeda australis*, *Poa sieberiana*, *Poa labillardieri*, *Acaena novae-zelandiae*, *Acaena ovina*, *Viola betonicifolia*, *Dichondra repens*, *Wahlenbergia stricta* subsp. *stricta*, *Bracteantha bracteata*, *Desmodium varians*, *Scleranthus biflorus*, *Diuris abbreviata*, *Galium ciliare*, *Hypericum gramineum*, *Ranunculus lappaceus*

Indicator native species: *Eucalyptus viminalis*, *Ranunculus lappaceus*, *Pultenaea microphylla*, *Ammobium alatum*

Common exotic species: *Hypochaeris radicata*, *Trifolium repens*, *Cirsium vulgare*, *Taraxacum officinale*, *Petrorhagia nanteullii*

Variability: Community 6 is similar to community 7 in the floristic composition of the understorey. The tall forest of *Eucalyptus viminalis* and *Eucalyptus dalrympleana* subsp. *heptantha* would have originally dominated much of the basalt plateau and is now only surviving in small remnants. *Eucalyptus pauciflora* is more common on the highest (coldest) ridges and in cold air drainage valleys.

Condition: Poor. Mostly cleared with less than 10% of this community remaining and much of that is regrowth or has had its understorey adversely

Fig. 17. Community 6, *Eucalyptus viminalis-Eucalyptus dalrympleana* subsp. *heptantha* on undulating basalt plateau near Guyra. Less than 15% of this forest type is estimated to remain uncleared and most remnants are in poor condition.

affected by grazing or weed invasion. The best remnants are along roadsides such as the New England Highway.

Threats: An endangered plant community threatened by further clearing of remnants, grazing of understorey and weed invasion.

Threat status: Guyra: E(i); **NSW:** E(i)

Reservation code: Guyra: VP; **NSW:** VP

No. reserves in study area containing this community: 1; **Area reserved:** 17 ha

Conservation status: Small area held in Llangothlin Nature Reserve.

Key sites for conservation: Site 10 Crown reserve south of Ben Lomond on Wandsworth Road; the road reserve (including sites 6 and 7) on the New England Highway; site 155 on Baldersleigh Road (which has a population of the rare plant *Thesium australe)*; sites 180, 181 and 182 along Aberfoyle Road for *Thesium australe*; sites 186 and 187 on the top of Mount Ben Lomond; and site 310 on the ridge above the Lagoon Farm wetland.

Community 7: Black Sallee (*Eucalyptus stellulata*)-Snow Gum (*Eucalyptus pauciflora*) Low Open Forest or Low Open Woodland with a grassy understorey

Equivalent in Hager and Benson (1994): EF412a; **Forest Type:** 137

Note: Community 7 has a lower canopy height (< 12 m) than community 6 and is dominated by Black Sallee while community 6 is a taller (> 12 m) forest dominated by Ribbon Gum or Mountain Gum. The two communities were distinguished for the vegetation map through aerial photographic interpretation and field traverse.

Sample sites (4): 184, 194, 251, 254

Landform, substrate and soils: Mainly confined to the high undulating, basalt plateau centred on Guyra with deep, chocolate or krasnozem loam soils. Often on valley sides or swampy depressions. Sometimes on other soil types.

Distribution: Mainly confined to the Guyra plateau from Ben Lomond in the north to Black Mountain in the south.

Extant area: native understorey: 606 ha; exotic understorey: 1213 ha; **Total:** 1819 ha

Estimated remaining extent of pre-European extent: 10%

Structure: Low open forest or low woodland with trees less then 12m high and generally with a mid-dense to open crown cover (10–50%).

No. native species: 86; **Mean no. per site:** 34.5 +/-6.2

No. exotic species: 28; **Mean no. per site:** 12 +/- 4.7

Common native species:

- Trees: *Eucalyptus stellulata*, *Eucalyptus pauciflora*
- Shrubs: *Acacia dealbata*, *Pultenaea microphylla*, *Pimelea linifolia*
- Ground cover: *Geranium solanderi* var. *solanderi*, *Hydrocotyle laxiflora*, *Glycine clandestina*, *Rubus parvifolius*, *Asperula conferta*, *Poa sieberiana*, *Acaena novae-zelandiae*, *Dichondra repens*, *Hypericum gramineum*, *Scleranthus biflorus*, *Wahlenbergia stricta* subsp. *stricta*

Indicator native species: *Eucalyptus stellulata*, *Ammobium alatum*

Common exotic species: *Acetosella vulgaris*, *Hypochaeris radicata*, *Trifolium repens*, *Cirsium vulgare*, *Taraxacum officinale*, *Rubus ulmifolius*

Variability: Crown cover varies considerably depending on degree of thinning or regrowth.

Condition: Poor. Mostly cleared with less than 10% of this community remaining and much of that is regrowth or has had its understorey altered by grazing or pasture weed invasion.

Threats: An endangered plant community threatened by further clearing of remnants, grazing of understorey and weed invasion.

Threat status: Guyra: E(i); **NSW:** V(i)

Reservation code: Guyra: VP; **NSW:** M

No. reserves in study area containing this community: 1; **Area reserved:** 27 ha

Conservation status: Small area held in Llangothlin Nature Reserve.

Community 8: New England Peppermint (*Eucalyptus nova-anglica*) Woodland on Basalt (Fig. 18)

Equivalent in Hager and Benson (1994): EF517a; **Forest Type:** 142

Sample sites: not sampled-nearly extinct.

Landform, substrate and soils: Base of valleys on basalt plateaux.

Fig. 18. Community 8, affected by dieback. New England Peppermint *Eucalyptus nova-anglica* on basalt (community 8) near Guyra. This community has been extensively cleared and only a few patches remain.

Distribution: Mainly confined to the basalt plateau around Guyra.

Extant area: native understorey: 172 ha; exotic understorey: 173 ha; **Total:** 345 ha

Estimated remaining extent of pre-European extent: 5%

Structure: Woodland, tree height varies from 8–20 m with a sparse (up to 30%) cover. Few shrubs are present but ground cover is usually dense.

No. native species: NA; **Mean no. per site:** NA

No. exotic species: NA; **Mean no. per site:** NA

Common native species:

- Trees: *Eucalyptus nova-anglica*
- Shrubs: No common shrubs
- Ground cover: *Poa sieberiana, Asperula conferta* and other grasses and forbs

Indicator native species: NA

Common exotic species: NA

Variability: NA

Condition: Nearly extinct. Almost entirely cleared and what remains has been affected by dieback and the understorey has been heavily grazed.

Threats: A critically endangered plant community threatened by further clearing of remnants, dieback, grazing of understorey, weed invasion.

Threat status: Guyra: CE(i); **NSW:** CE(i)

Reservation code: Guyra: VP; **NSW:** VP

No. reserves in study area containing this community: 0; **Area reserved:** 0

Conservation status: Not reserved

Key sites for conservation: Few remnants remain. Patches occur along Wards Mistake and Handebos Roads east of Guyra township.

Community 9: New England Peppermint (*Eucalyptus nova-anglica*) Woodland on Sediments (Fig. 19)

Equivalent in Hager and Benson (1994): EF517a; **Forest Type:** 142

Sample sites (7)**:** 15, 67, 93, 96, 191, 216, 222

Landform, substrate and soils: Valley flats subject to cold air drainage composed of fine-grained sedimentary and acid volcanic substrates with poorly drained loam-clay soils.

Fig. 19. Community 9, *Eucalyptus nova-anglica* regrowth woodland on sedimentary rock at site 67, 5 km to the east of Armidale. This woodland has been severely affected by dieback over the last two decades.

Distribution: Mainly confined to the southern section of the study area near Armidale and Boorolong, and in the western section on the Tingha Road near Wandsworth; at elevations 900–1180 m.

Extant area: native understorey: 1167 ha; exotic understorey: 812 ha; **Total:** 1979 ha

Estimated remaining extent of pre-European extent: 15%

Structure: Woodland, tree height varies from 8–20 m with a sparse (up to 30%) cover. Few shrubs are present but ground cover is usually dense.

No. native species: 94; **Mean no. per site:** 27 +/- 3

No. exotic species: 29; **Mean no. per site:** 9 +/- 7

Common native species:

- Trees: *Eucalyptus nova-anglica* occasionally with *Eucalyptus dalrympleana* subsp. *heptantha*
- Shrubs: No common shrubs
- Ground cover: *Asperula conferta*, *Themeda australis*, *Juncus filicaulis*, *Dichondra repens*, *Carex inversa*, *Rumex brownii*, *Acaena ovina*, *Desmodium varians*

Indicator native species: *Eucalyptus nova-anglica*, *Carex inversa*, *Haloragis heterophylla*, *Juncus filicaulis*, *Cymbonotus lawsonianus*, *Leucopogon fraseri*

Common exotic species: *Hypochaeris radicata*, *Aira elegantissima*, *Rosa rubiginosa*

Variability: Variation is present in structure due to stages of regrowth after clearing or dieback.

Condition: Poor. Mostly cleared and what remains has been severely affected by dieback and the understorey has been heavily grazed.

Threats: An endangered plant community threatened by further clearing of remnants, dieback, grazing of understorey, weed invasion.

Threat status: Guyra: E(i); **NSW:** E(i)

Reservation code: Guyra: VP; **NSW:** VP

No. reserves in study area containing this community: 2; **Area reserved:** 54 ha

Conservation status: Small areas are sampled in Duval and Boorolong Nature Reserves. Remnants also occur in some TSRs and road reserves.

Key sites for conservation: Sites 15 and 191 on Tingha Road, site 93 Rockvale Road at Wollomombi River, site 67 also on Rockvale Road.

Community 10: New England Peppermint (*Eucalyptus nova-anglica*)-Snow Gum (*Eucalyptus pauciflora*) Open Forest on Granite and Leucogranite (Fig. 20)

Equivalent in Hager and Benson (1994): EF517b; **Forest Type:** 142

Sample sites (9)**:** 17, 22, 37, 44, 115, 140, 143, 235, 246

Landform, substrate and soils: Flats and lower slopes subject to cold air drainage, on granite and leucogranite substrates with poorly drained yellow-brown sandy loam soils.

Distribution: North-eastern section of the study area including Backwater, Sara River, Oban River at elevations 980–1280 m.

Extant area: native understorey: 4040 ha; exotic understorey: 418 ha; **Total:** 4458 ha

Estimated remaining extent of pre-European extent: 25%

Structure: Open forest, trees 18 m high with a mid-dense (30–50%) cover with a sparse shrub cover but with tall grasses or bracken (*Pteridium esculentum*), and a dense ground cover.

No. native species: 126; **Mean no. per site:** 35 +/- 9

No. exotic species: 28; **Mean no. per site:** 6 +/- 2

Common native species:

- Trees: *Eucalyptus nova-anglica*, *Eucalyptus pauciflora*, *Eucalyptus stellulata*
- Shrubs: *Rubus parvifolius*, *Bursaria spinosa*, *Leucopogon fraseri*
- Ground cover: *Themeda australis*, *Pteridium esculentum*, *Glycine clandestina*, *Acaena novae-zelandiae*, *Scleranthus biflorus*, *Hypericum gramineum*, *Poa sieberiana*, *Imperata cylindrica*

Indicator native species: *Eucalyptus stellulata*, *Eucalyptus pauciflora*, *Grevillea juniperina*

Common exotic species: *Hypochaeris radicata*, *Trifolium repens*, *Acetosella vulgaris*, *Holcus lanatus*

Variability: Forest height varies, being taller along the Oban River where Mountain Gum (*Eucalyptus dalrympleana* subsp. *heptantha*) is present. There is also more *Pteridium* and *Imperata* along the Oban River, perhaps indicating more frequent fire in that area.

Condition: Poor. Mostly cleared and only small remnants remain. Dieback has severely impacted on this community.

Threats: Further clearing and dieback, tin-mining and grazing of remnants. Not reserved and one of the most endangered plant communities on the New England Tableland.

Threat status: Guyra: E(i); **NSW:** E(i)

Reservation code: Guyra: VP; **NSW:** VP

No. reserves in study area containing this community: 1; **Area reserved:** 2 ha

Conservation status: Tiny portion of this community is within Warra National Park.

Key sites for conservation: Site 235 near Granite Springs, site 143 adjacent to Oban River, site 22 Wards Mistake Road, site 37 Sara River.

Community 11: Broad-leaved Stringybark (*Eucalyptus caliginosa*)-Mountain Gum (*Eucalyptus dalrympleana* subsp. *heptantha*) Open Forest on Leucogranite (Fig. 21)

Equivalent in Hager and Benson (1994): EF413c; **Forest Type:** nil

Sample sites (13): 3, 20, 33, 41, 55, 58, 60, 64, 65, 256, 261, 264, 265

Landform, substrate and soils: Flats and lower slopes on leucogranite substrate with sandy, low nutrient soil.

Distribution: Confined to the north-eastern section of the study area between Backwater, Mount Mitchell and Paddys Gully Road at elevations 1020–1240 m.

Extant area: native understorey: 4356 ha; exotic understorey: 41 ha; **Total:** 4397 ha

Estimated remaining extent of pre-European extent: 60%

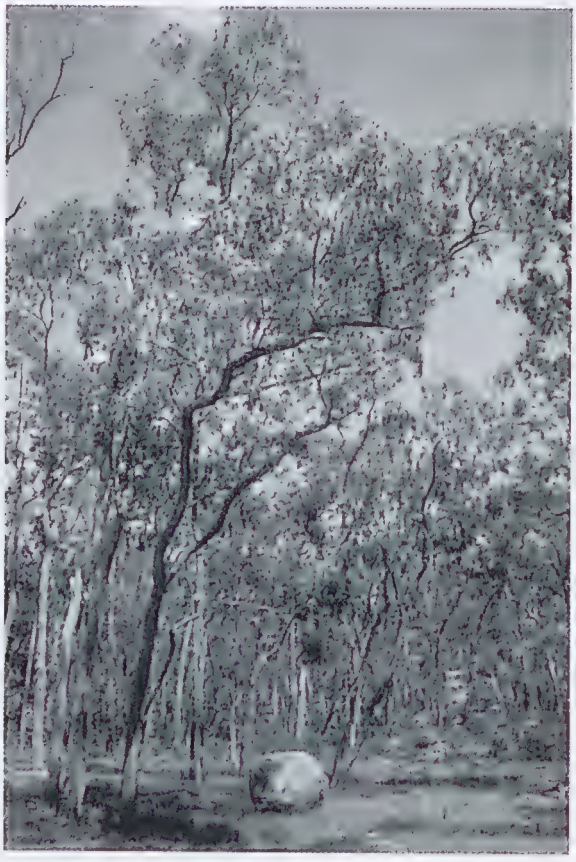

Fig. 20. Community 10, on leucogranite on the property Wattleridge near Backwater showing New England Peppermint (*Eucalyptus nova-anglica*).

Structure: Open forest, trees 20 m mid-dense-dense (30–80%) crown cover. One to several shrub layers present, sparse to mid-dense. Ground cover sparse to mid-dense.

No. native species: 168; **Mean no. per site:** 42 +/- 7

No. exotic species: 4; **Mean no. per site:** 1.4 +/- 0.8

Common native species:

- Trees: *Eucalyptus caliginosa*, *Eucalyptus dalrympleana* subsp. *heptantha* occasionally *Eucalyptus radiata* subsp. *sejuncta*
- Shrubs: *Persoonia cornifolia*, *Bossiaea scortechinii*, *Acacia filicifolia*, *Opercularia hispida*, *Hovea linearis*, *Banksia integrifolia* subsp. A, *Rubus parvifolius*, *Brachyloma daphnoides*
- Ground cover: *Pteridium esculentum*, *Goodenia hederacea* subsp. *hederacea*, *Themeda australis*, *Stylidium graminifolium*, *Gonocarpus tetragynus*, *Dichelachne micrantha*, *Imperata cylindrica*

Indicator native species: *Eucalyptus dalrympleana* subsp. *heptantha*, *Bossiaea scortechinii*, *Hovea linearis*, *Stylidium graminifolium*

Common exotic species: *Hypochaeris radicata*

Variability: Little variation in species mix. Site 20 on Paddys Gully Road lacks *Eucalyptus dalrympleana* subsp. *heptantha* and contains *Jacksonia scoparia* as an understorey dominant.

Condition: While clearing has eliminated some areas, intact patches remain that are in good condition lacking weeds and have not been affected by dieback.

Threats: The main threat is the continual clearing of this marginal agricultural land by traditional and hobby farmers, although this community is less threatened than communities 8, 9 and 10.

Threat status: Guyra: NT(i); **NSW**: LC(i)

Reservation code: Guyra: P; **NSW:** M

No. reserves in study area containing this community: 1; **Area reserved:** 56 ha

Conservation status: Poorly represented in reserves but it is sampled in Warra National Park.

Key sites for conservation: Most sites are in good condition and warrant protection. Of particular importance are sites 55 and 261 on 'Wattleridge' and sites 58 and 256 on portion 14, Parish of Hall, County Clarke. These two properties contain the largest and most intact vegetation remnant in the study area. They contain outstanding conservation values for a number of plant communities and rare plant species.

Fig. 21. Community 11, *Eucalyptus caliginosa-Eucalyptus dalrympleana* subsp. *heptantha* on flats on leucogranite at site 41 in Warra State Forest northeast of Backwater.

Community 12: New England Blackbutt (*Eucalyptus campanulata*) Open Forest on Leucogranite (Fig. 22).

Equivalent in Hager and Benson (1994): EF505a,b,c; **Forest Type:** 163

Sample sites (18)**:** 19, 54, 57, 62, 63, 116, 120, 129, 133, 233, 234, 236, 242, 243, 244, 258, 259, 260

Landform, substrate and soils: Rocky ridges and upper slopes on leucogranite with shallow, low nutrient, sandy soils.

Distribution: Confined to the leucogranite outcrop north-east of Backwater at elevations 1100–1300 m.

Extant area: native understorey: 2118 ha; exotic understorey: 0 ha; **Total:** 2118 ha

Estimated remaining extent of pre-European extent: 90%

Structure: Open forest, trees 15–20 m high mid-dense (30–50%) crown cover. Very sparse, small tree layer of *Allocasuarina littoralis* often present. Shrub and ground layers sparse to mid dense.

No. native species: 161; **Mean no. per site:** 34 +/-8.0

No. exotic species: 6; **Mean no. per site:** 0.5 +/-0.8

Common native species:

- Trees: *Eucalyptus campanulata* with *Eucalyptus caliginosa* or *Eucalyptus radiata* subsp. *sejuncta*
- Shrubs: *Lomatia silaifolia*, *Allocasuarina littoralis*, *Persoonia cornifolia*, *Monotoca scoparia*, *Brachyloma daphnoides*, *Banksia integrifolia* subsp. A
- Ground cover: *Goodenia hederacea* subsp. *hederacea*, *Gonocarpus tetragynus*, *Pteridium esculentum*, *Entolasia stricta*, *Poranthera microphylla*

Indicator native species: *Eucalyptus campanulata*, *Eucalyptus cameronii*, *Pomax umbellata*, *Patersonia sericea*, *Allocasuarina littoralis*

Common exotic species: *Hypochaeris radicata*

Variability: Associate tree species vary, for example at site 260 on 'Wattleridge', *Eucalyptus acaciiformis* is dominant. Understorey varies with aspect and fire history, for example site 242 upslope from Backwater Creek is dominated by the fern *Gleichenia dicarpa*. Some large leucogranite boulders provide habitat for ferns.

Condition: Good condition. Little affected by clearing due to its presence on rough terrain. Very few weeds.

Fig. 22. Community 12, dominated by *Eucalyptus campanulata*, commonly occurs on leucogranite ridges in the Backwater region.

Threats: As this community occurs on rocky low nutrient terrain it is not threatened, although there is some clearing of this non-agricultural land by hobby farmers.

Threat status: Guyra: LC(ii); **NSW:** LC(i)

Reservation code: Guyra P; **NSW:** M

No. reserves in study area containing this community: 1; **Area reserved:** 126 ha

Conservation status: Poorly represented in reserves but it is sampled in Warra National Park.

Key sites for conservation: Most remaining areas are in good condition. A number of rare species occur in this community. If the eastern part of 'Wattleridge' and portion 14 Parish Hall were protected in a reserve, this community would be classed as well conserved.

Community 13: Silver-top Stringybark (*Eucalyptus laevopinea*)-Forest Ribbon Gum (*Eucalyptus nobilis*) Open Forest on Sediments

Equivalent in Hager and Benson (1994): EF479d; **Forest Type:** 167

Sample sites (4)**:** 100, 101, 262, 273

Landform, substrate and soils: Ridges and slopes on fine-grained sedimentary substrate with light brown, clay soil.

Distribution: Restricted to Avondale State Forest and nearby areas in the south-east of the study area at elevations 1180–1250 m.

Extant area: native understorey: 923 ha; exotic understorey: 0 ha; **Total:** 923 ha

Estimated remaining extent of pre-European extent: 30%

Structure: Open to closed forest, trees 20 m with a dense (50–80%) crown cover probably due to dense regrowth after logging or thinning. Shrub layer absent or very sparse. Ground cover very sparse.

No. native species: 22; **Mean no. per site:** 15 +/- 3

No. exotic species: 2; **Mean no. per site:** 1.5 +/- 0.7

Common native species:

- Trees: *Eucalyptus laevopinea*, *Eucalyptus nobilis*, *Eucalyptus radiata* subsp. *sejuncta*
- Shrubs: *Melichrus urceolatus*, *Lissanthe strigosa*, *Indigofera australis*
- Ground cover: *Poa sieberiana*, *Lomandra multiflora* subsp. *multiflora*, *Hardenbergia violacea*

Indicator native species: *Eucalyptus nobilis*, *Indigofera australis*, *Brachyscome microcarpa*

Common exotic species: *Hypochaeris radicata*

Variability: Uniform, some variation in understorey.

Condition: Much of the forest is regrowth after logging. Grazing may have reduced the biomass in the understorey.

Threats: Much of this stringybark forest has been cleared, although remnants remain in and around Avondale State Forest. Logging and clearing remain the main threats.

Threat status: Guyra: V(i); **NSW:** NT(i)

Reservation code: Guyra: VP; **NSW:** P

No. reserves in study area containing this community: 0; **Area reserved:** 0

Conservation status: Not reserved. Located in Avondale State Forest which could be reserved.

Key sites for conservation: Avondale State Forest

Community 14: Narrow-leaved Peppermint (*Eucalyptus radiata* subsp. *sejuncta*)-Forest Ribbon Gum (*Eucalyptus nobilis*)-*Hovea* sp. A Open-Closed Forest (Fig. 23)

Equivalent in Hager and Benson (1994): nil; **Forest Type:** 111

Sample site (3)**:** 163, 164, 275

Landform, substrate and soils: Ridgelines on granite substrate with shallow sandy-loam soil.

Distribution: Naturally restricted community occurring on Mount Nobbler near Backwater in the north-western section of the study area at elevations 1330–1390 m.

Extant area: native understorey: 512 ha; exotic understorey: 0 ha; **Total:** 512 ha

Estimated remaining extent of pre-European extent: 90%

Structure: Open to closed forest (50–80%) crown cover, trees 14 m high, dense shrub cover, sparse ground cover.

No. native species: 45; **Mean no. per site:** 27 +/- 4

No. exotic species: 1; **Mean no. per site:** -

Common native species:

- Trees: *Eucalyptus radiata* subsp. *sejuncta*, *Eucalyptus nobilis*
- Shrubs: *Hovea* sp. A, *Lomatia silaifolia*, *Leucopogon lanceolatus*, *Platysace ericoides*, *Monotoca scoparia*

Fig. 23. Community 14, *Eucalyptus radiata* subsp. *sejuncta-Eucalyptus nobilis* with a dense understorey dominated by *Hovea* sp A, is restricted to ridges near Mount Nobbler, 3 km northwest of Backwater.

- Ground cover: *Poa sieberiana*, *Poranthera microphylla*, *Lomandra longifolia*, *Hardenbergia violacea*

Indicator native species: *Hovea* sp. A, *Olearia oppositifolia*, *Platysace ericoides*

Common exotic species: None.

Variability: Density of the understorey varies, perhaps due to fire history.

Condition: Very good. Only one weed recorded and not subject to clearing due to the terrain.

Threats: Not threatened as it occurs on steep, rocky ridges. Subject to grazing and some logging.

Threat status: Guyra: LC(iii); **NSW:** LC (iii)

Reservation code: Guyra: VP; **NSW:** VP

No. reserves containing this community: 0; **Area reserved:** 0

Conservation status: Not reserved.

Key sites for conservation: Area including sites 163 and 164 on Mount Nobbler.

Community 15: Forest Ribbon Gum (*Eucalyptus nobilis*) -Broad-leaved Stringybark (*Eucalyptus caliginosa*) Open Forest on Leucogranite (Fig. 24)

Equivalent in Hager and Benson (1994): EF414b; **Forest Type:** 160

Sample sites (10)**:** 34, 35, 38, 40, 118, 126, 128, 131, 245, 255

Landform, substrate and soils: Flats and lower slopes on leucogranite substrate with deep, low nutrient, sandy-loam soils.

Distribution: Leucogranite outcrop north of Backwater, particularly near Mount Mitchell in the north-eastern section of the study area, at elevations 1090–1270 m.

Extant area: native understorey: 811 ha; exotic understorey: 0 ha; **Total:** 811 ha

Estimated remaining extent of pre-European extent: 60%

Structure: Open forest to tall open forest, trees 15–25 m high, mid-dense to dense (30–80%) cover. Sparse small tree layer usually present. Shrub layer mid-dense with a sparse ground cover.

Fig. 24. Community 15, *Eucalyptus radiata* subsp. *sejuncta-Eucalyptus nobilis* open forest with an understorey dominated by *Monotoca scoparia* at site 34, 2 km east of Mount Mitchell.

No. native species: 146; **Mean no. per site:** 46 +/-8

No. exotic species: 4; **Mean no. per site:** 1.5 +/-1

Common native species:

- Trees: *Eucalyptus caliginosa*, *Eucalyptus nobilis*, *Eucalyptus radiata* subsp. *sejuncta*, *Banksia integrifolia* subsp. A
- Shrubs: *Leucopogon lanceolatus*, *Senecio* sp. E, *Rubus parvifolius*, *Acacia filicifolia*, *Persoonia cornifolia*, *Monotoca scoparia*
- Ground cover: *Poa sieberiana*, *Poranthera microphylla*, *Pteridium esculentum*, *Glycine clandestina*, *Geranium solanderi* var. *solanderi*, *Viola betonicifolia*, *Lomandra longifolia*, *Imperata cylindrica*, *Gonocarpus tetragynus*

Indicator native species: *Lomandra filiformis* subsp. *filiformis*, *Acacia filicifolia*, *Viola hederacea*, *Brachyscome nova-anglica*

Common exotic species: *Hypochaeris radicata*

Variability: Understorey varies depending on aspect and recovery period from last fire.

Condition: Good. Little disturbed because it occurs on poor soils.

Threats: Subdivision of land and subsequent development is the main threat to this plant community.

Threat status: Guyra: NT(ii); **NSW:** NT(ii)

Reservation code: Guyra: P; **NSW:** P

No. reserves in study area containing this community: 1; **Area reserved:** 115 ha

Conservation status: A small area is reserved in Warra National Park.

Key sites for conservation: Areas near Mount Mitchell and Portion 14, Parish of Hall are key locations for conserving this community, including sites 126, 128, 131, 255.

Community 16: Broad-leaved Stringybark (*Eucalyptus caliginosa*)-Forest Ribbon Gum (*Eucalyptus nobilis*)-Blakely's Red Gum (*Eucalyptus blakelyi*) Open Forest, Oban River (Fig. 25)

Equivalent in Hager and Benson (1994): EF413c; **Forest Type:** 160

Sample sites (5): 139, 142, 144, 145, 267

Landform, substrate and soils: Slopes and ridges on granite substrate with sandy-loam soils.

Fig. 25. Community 16, *Eucalyptus nobilis-Eucalyptus caliginosa* open forest on ridges and slopes above the Oban River, 8 km east of Backwater.

Distribution: Oban River and Wards Mistake in the north-eastern section of the study area at elevations 1050–1270 m.

Extant area: native understorey: 824 ha; exotic understorey: 1 ha; **Total:** 825 ha

Estimated remaining extent of pre-European extent: 50%

Structure: Open forest, trees 15–20m high with mid-dense (30–50%) crown cover. Shrubs absent or very sparse, ground cover dense and dominated by grasses.

No. native species: 84; **Mean no. per site:** 36 +/- 6

No. exotic species: 4; **Mean no. per site:** 2 +/- 0.7

Common native species:

- Trees: *Eucalyptus caliginosa*, *Eucalyptus nobilis*, *Eucalyptus blakelyi*
- Shrubs: *Rubus parvifolius*, *Opercularia hispida*
- Ground cover: *Pteridium esculentum*, *Lomandra longifolia*, *Imperata cylindrica*, *Dichelachne micrantha*, *Cymbopogon refractus*, *Poa sieberiana*, *Glycine clandestina*

Indicator native species: *Cheilanthes distans*, *Plectranthus parviflorus*, *Cymbopogon refractus*, *Brachyscome tenuiscapa* var. *pubescens*

Common exotic species: *Hypochaeris radicata*

Variability: *Eucalyptus blakelyi* is present on the lower slopes. The understorey is consistently dominated by grasses.

Condition: Average. Extensive areas cleared on lower slopes and in valleys. Remnants grazed.

Threats: Clearing, grazing, logging and too-frequent fire threaten this community.

Threat status: Guyra: V(ii); **NSW:** V(ii)

Reservation code: Guyra: VP; **NSW:** VP

No. reserves in study area containing this community: 0; **Area reserved:** 0

Conservation status: Not reserved, mostly found on private land.

Key sites for conservation: Sites 139 and 142 on ridge on the eastern side of Oban River, and sites 144 and 145 on the ridge on the western side of the Oban River.

Community 17: Messmate (*Eucalyptus obliqua*)-Forest Ribbon Gum (*Eucalyptus nobilis*) Tall Open Forest (Fig. 26)

Equivalent in Hager and Benson (1994): EF475c; **Forest Type:** 152

Sample sites (35): 16, 27, 42, 52, 56, 61, 107, 117, 130, 134, 135, 136, 137, 138, 150, 151, 152, 153, 154, 162, 165, 168, 169, 170, 173, 174, 210, 211, 212, 247, 257, 263, 266, 279, 280

Landform, substrate and soils: Mainly on protected eastern or southern slopes, occasionally extending onto ridges. Occurring most frequently on granite and leucogranite substrates but also acid volcanics with most often a sandy-loam soil.

Distribution: Mainly east of the Great Dividing Range where rainfall is higher than western areas. Occurs in Mount Duval Nature Reserve, on Little Duval and with a small stand in Boorolong Nature Reserve in the south-western section of the study area. Most common on Days Ridge and Mount Duncan in the north-eastern section of the study area. Also present on leucogranite at Mount Nobbler, Crown Mountain and 'Wattleridge'. Generally at elevations above 1300 m but its occurrences range from 1040–1400 m.

Extant area: native understorey: 2888 ha; exotic understorey: 5 ha; **Total:** 2893 ha

Estimated remaining extent of pre-European extent: 80%

Structure: Tall open forest, trees usually > 25 m high (up to 40 m at site 56 at 'Wattleridge'), crown cover dense (50–80%). Sparse small tree layer often present. Shrubs very sparse, ground cover mid-dense.

No. native species: 189; **Mean no. per site:** 31 +/- 9

No. exotic species: 29; **Mean no. per site:** 4 +/- 3

Common native species:

- Trees: *Eucalyptus obliqua*, *Eucalyptus nobilis*, *Eucalyptus radiata* subsp. *sejuncta*, *Banksia integrifolia* subsp. A
- Shrubs: *Rubus parvifolius*, *Leucopogon lanceolatus*, *Senecio* sp. E, *Lomatia silaifolia*
- Ground cover: *Acaena novae-zelandiae*, *Pteridium esculentum*, *Poa sieberiana*, *Geranium solanderi* var. *solanderi*, *Dichondra repens*, *Desmodium varians*, *Smilax australis*, *Wahlenbergia stricta*, *Galium ciliare*, *Hydrocotyle laxiflora*

Fig. 26. Community 17, *Eucalyptus obliqua-Eucalyptus nobilis* tall open forest occurs on protected aspects of a number of mountain ranges that receive higher rainfall than surrounding valleys. The understorey varies from mesic to dry, the latter shown here at site 135 on 'Mount View' Days Ridge, where *Lomandra longifolia* dominates.

Indicator native species: *Eucalyptus nobilis, Hydrocotyle geraniifolia, Asplenium flabellifolium*

Common exotic species: *Hypochaeris radicata, Cirsium vulgare, Trifolium repens*

Variability: This group could be divided into three subgroups based on the UPGMA analysis: 1. Sites on Mount Nobbler, Mount Duncan and Days Ridge which are high and wet and contain moist understorey species; 2. Those on the acid volcanics on and near Little Duval which contain a drier understorey; 3. Occurrences on the leucogranite north east of Backwater which contain a number of different understorey species normally found on poorer soils.

Condition: Generally good as this community occurs on high, steep hillsides that have not been totally cleared. Large remnants remain. Some areas have been heavily logged and grazed.

Threats: Isolated clearing continues (for example on the southern side of Mount Nobbler). Heavy logging is threatening the structure of the community in some places, such as Days Ridge. Grazing is less of a threat.

Threat status: Guyra: LC(i); **NSW:** LC(i)

Reservation code: Guyra: M; **NSW**: AC

No. reserves in study area containing this community: 3; **Area reserved:** 179 ha

Conservation status: Moderately well conserved. Represented in Warra National Park, Mount Duval Nature Reserve and Boorolong Nature Reserve.

Key sites for conservation: Other then the present reserves, areas suitable for protection include Little Duval, sections of Days Ridge and Mount Duncan, Mount Nobbler (site 162) and sections of 'Wattleridge'.

Community 18: Narrow-leaved Peppermint (*Eucalyptus radiata* subsp. *sejuncta*)-Wattle-leaved Peppermint (*Eucalyptus acaciiformis*) Open Forest on Granite (Fig. 27)

Equivalent in Hager and Benson (1994): EF515b; **Forest Type:** 111

Sample sites (20)**:** 18, 21, 48, 97, 121, 122, 123, 124, 125, 146, 147, 148, 149, 192, 193, 214, 268, 270, 272, 274

Landform, substrate and soils: Exposed plateaux, ridges and slopes mainly on granite substrates with sandy clay soils.

Distribution: Mainly restricted to the north-eastern section of the study area along Wards Mistake Road,

Fig. 27. Community 18 is often dominated by *Eucalyptus radiata* subsp. *sejuncta* with a stratum of small trees of *Banksia integrifolia* subsp. A. This shows site 274 north of the Sara River north west of Backwater on granite substrate.

between Backwater and Llangothlin Lagoon, Aberfoyle Road, Days Ridge and near Backwater, at elevations 1090–1400 m.

Extant area: native understorey: 6753 ha; exotic understorey: 308 ha; **Total:** 7061 ha

Estimated remaining extent of pre-European extent: 40%

Structure: Open forest, trees 15 m high, mid-dense to dense (30–80%) crown cover with a very sparse shrub layer and mid-dense to dense ground cover.

No. native species: 173; **Mean no. per site:** 33 +/- 10

No. exotic species: 26; **Mean no. per site:** 5 +/- 3

Common native species:

- Trees: *Eucalyptus radiata* subsp. *sejuncta*, *Eucalyptus acaciiformis*, occasionally *Eucalyptus pauciflora*, *Banksia integrifolia* subsp. A
- Shrubs: *Rubus parvifolius*, *Senecio* sp. E
- Ground cover: *Poa sieberiana*, *Dichondra repens*, *Pteridium esculentum*, *Glycine clandestina*, *Geranium solanderi* var. *solanderi*, *Desmodium varians*, *Acaena novae-zelandiae*

Indicator native species: *Eucalyptus acaciiformis*

Common exotic species: *Hypochaeris radicata*, *Trifolium repens*, *Rubus ulmifolius*

Variability: Trees such as *Eucalyptus caliginosa and Eucalyptus dalrympleana* subsp. *heptantha* occur at some sites.

Condition: Varies from good to poor depending on the degree of clearing and grazing. Some roadside remnants are in excellent condition. Some remnants are heavily grazed, thinned and affected by dieback.

Threats: As this community mainly occurs on private land, further clearing and heavy grazing threaten some areas. Dieback affects isolated small patches of forest.

Threat status: Guyra: V(i); **NSW:** V(i)

Reservation code: Guyra: VP; **NSW:** P

No. reserves in study area containing this community: 0; **Area reserved :** 0

Conservation status: Not reserved.

Key sites for conservation: Sites 21 and 122 on road reserve along Wards Mistake Road; site 273 on 'Stonebrook', site 268 at Beesnest Hill on 'Sunnyside' (contains a good patch of the rare *Thesium australe*); Day Trig area.

Community 19: Wattle-leaved Peppermint (*Eucalyptus acaciiformis*)-Broad-leaved Stringybark (*Eucalyptus caliginosa*)-Narrow-leaved Peppermint (*Eucalyptus radiata* subsp. *sejuncta*) Open Forest on Sediments (Fig. 28)

Equivalent in Hager and Benson (1994): EF515b,e; Forest Type: 111
Sample site (3)**:** 24, 95, 183

Landform, substrate and soils: Undulating terrain composed of fine grain sedimentary rocks and clayey soils.

Distribution: Rockvale Road and Macleay Range, north-east of Armidale, at 1200 m elevation.

Extant area: native understorey: 489 ha; exotic understorey: 20 ha; **Total:** 509 ha

Estimated remaining extent of pre-European extent: 20%

Structure: Open-forest with trees 8–14m high with a 35–50% crown cover, shrubs sparse, dense ground cover dominated by grasses and forbs.

No. of native species: 63; **Mean no. per site:** 40 +/- 2

No. exotic species: 13; **Mean no. per site:** 6 +/- 2

Common native species:

- Trees: *Eucalyptus acaciiformis*, *Eucalyptus radiata* subsp. *sejuncta*, *Eucalyptus caliginosa*
- Shrubs: *Allocasuarina littoralis*, *Acacia filicifolia*, *Ozothamnus diosmifolia*
- Ground cover: *Poa sieberiana*, *Themeda australis*, *Chrysocephalum apiculatum*

Indicator native species: NA

Common exotic species: *Hypochaeris radicata*, *Trifolium* species

Variability: Analysis revealed that this community shares many species with community 2 which also occurs on sediments in the area. Much of the forest is regrowth in variable sized patches.

Condition: Poor. Mostly cleared for agriculture and most remnants are grazed. Remnants along roadsides have better developed understoreys.

Threats: Further clearing, grazing of understorey, road-widening.

Threat status: Guyra: E(ii); **NSW:** E(ii)

Reservation code: Guyra: VP; **NSW:** VP

No. reserves in study area containing this community: 0; **Area reserved:** 0

Fig. 28. Community 19, *Eucalyptus acaciiformis* low open forest on sedimentary substrate near Rockvale Road east of Armidale. Only small remnants of this community remain. Floristically it has affinity to Community 2 — Broad-leaved Stringybark (*Eucalyptus caliginosa)* open forest on sediments.

Conservation status: Not reserved.

Key sites for conservation: Roadside remnants along Rockvale Road and Ebor Road. There may be better sites outside the study area.

Community 20: Heath Swamps on Leucogranite and Granite (Fig. 29)

Equivalent in Hager and Benson (1994): NA; Forest Type: 223

Sample site (5)**:** 4, 36, 51, 167, 171

Landform, substrate and soils: Valley swamps on leucogranite and granite acid-organic soils.

Distribution: North-east of Backwater and at Mount Duncan, at elevations 1200–1390 m.

Extant area: native understorey: 369 ha; exotic understorey: 0 ha; **Total:** 369 ha

Estimated remaining extent of pre-European extent: 80%

Structure: Open-closed shrubland/sedgeland, shrubs 1–2 m with 50–100% crown cover, with a dense sedgeland ground cover often growing in *Sphagnum* moss.

No. of native species: 92; **Mean no. per site:** 30 +/- 6

No. exotic species: 9; **Mean no. per site:** 20 +/- 4

Common native species:

- Trees: Generally absent, occasionally *Eucalyptus acaciiformis* present on margins.
- Shrubs: *Leptospermum gregarium, Baeckea gunniana, Lomatia fraseri, Hakea microcarpa, Epacris microphylla, Epacris breviflora, Banksia cunninghamii* subsp. A, *Callistemon pityoides*
- Ground cover: *Baloskion stenocoleus, Sphagnum cristatum* (a moss), *Lepyrodia anarthria, Gonocarpus micranthus, Schoenus apogon, Xanthorrhoea glauca* subsp. *glauca*

Indicator native species: *Baloskion stenocoleus, Sphagnum cristatum, Lepyrodia anarthria, Gonocarpus micranthus, Leptospermum gregarium, Callistemon pityoides, Hakea microcarpa, Baeckea gunniana, Epacris microphylla, Lomatia fraseri*

Common exotic species: None.

Variability: The density of the shrub layer varies between swamps due to hydrological differences or fire history, however the floristic assemblages are consistent.

Fig. 29. Community 20, heath swamp dominated by shrubs and sedges. These swamps occur on leucogranite near Backwater such as site 51 shown here in Kangaroo Gully.

Condition: Very good. Little disturbed by agriculture and not subject to heavy grazing.

Threats: Hobby farming activities in the Mount Mitchell and Sara River areas with some clearing, drainage and roadworks.

Threat status: Guyra: LC(ii); **NSW**: LC(ii)

Reservation code: Guyra: P; **NSW:** M

No. reserves in study area containing this community: 1; **area reserved:** 15 ha

Conservation status: Similar swamps are located in reserves outside the study area in the NET Bioregion, for example Bald Rock and Gibraltar Range National Parks. However, these swamps are poorly reserved in the study area with limited representation in Warra National Park.

Key sites for conservation: The reservation of the many swamps in portion 14, Parish Hall and on 'Wattleridge' would greatly improve the conservation status of this community.

Community 21: Mallee (*Eucalyptus codonocarpa*) and Heath on rocky outcrops on Leucogranite (Fig. 30)

Equivalent in Hager and Benson (1994): MA209a; **Forest Type:** 223, 225

Sample sites(6)**:** 5, 53, 59, 119, 166, 172

Landform, substrate and soils: Rocky ridges on leucogranite with skeletal, sandy soil.

Distribution: Restricted to the leucogranite outcrop north-east of Backwater including ridges near Paddys Gully, Mount Nobbler and Crown Mountain at elevations 1020–1400 m.

Extant area: native understorey: 241 ha; exotic understorey: 0 ha; **Total:** 241 ha

Estimated remaining extent of pre-European extent: 95%

Structure: Sparse (10–30%) crown cover of mallee or woodland, with mid-dense shrub layer interspersed with areas of bare rock, sparse ground cover.

No. native species: 98; **Mean no. per site:** 29 +/- 6

No. exotic species: 1; **Mean no. per site:** -

Common native species:

- Trees: *Eucalyptus codonocarpa*, *Eucalyptus caliginosa*
- Shrubs: *Leptospermum novae-angliae*, *Platysace lanceolata*, *Mirbelia confertiflora*, *Leucopogon neo-anglicus*, *Kunzea obovata*, *Hovea beckeri*, *Hibbertia linearis*, *Dillwynia phylicoides*, *Brachyloma saxicola*, *Acacia falciformis*, *Allocasuarina littoralis*

Fig. 30. Community 21, mallee and heath growing among leucogranite rocky outcrops at site 5 on the property Wattleridge north of Backwater.

- Ground cover: *Entolasia stricta*, *Lomandra longifolia*, *Lepidosperma gunnii*, *Patersonia glabrata*

Indicator native species: *Eucalyptus codonocarpa*, *Leucopogon neo-anglicus*, *Platysace lanceolata*, *Lepidosperma gunnii*, *Kunzea obovata*, *Hovea beckeri*, *Leptospermum novae-angliae*, *Acacia falciformis*, *Dillwynia phylicoides*, *Entolasia stricta*

Common exotic species: None.

Variability: Grades into community 11 along ridges. Some sites contain the mallee eucalypt *Eucalyptus codonocarpa*, others do not.

Condition: Very good. Due to its location on rocky ridges it has not been cleared or heavily grazed.

Threats: Hobby farm subdivision that could lead to increased disturbance and grazing by stock including goats.

Threat status: Guyra: LC(iii); **NSW:** LC(iii)

Reservation code: Guyra: P; **NSW:** AC

No. reserves in study area containing this community: 1; **Area reserved:** 4 ha

Conservation status: Sampled in Warra National Park and in other reserves north of the study area. If portion 14, Parish Hall and 'Wattleridge' were reserved this community would be well conserved.

Key sites for conservation: Sites on 'Wattleridge' and the adjoining portion 14, Parish of Hall.

Community 22: Narrow-leaved Peppermint (*Eucalyptus radiata* subsp. *sejuncta*)-Broad-leaved Stringybark (*Eucalyptus caliginosa*) Open Forest with dense shrubland on Leucogranite (Fig. 31)

Equivalent in Hager and Benson (1994): EF515e; **Forest Type:** 111

Sample sites (2)**:** 50, 132

Landform, substrate and soils: Flats on leucogranite with low nutrient, coarse, sandy soil.

Distribution: Restricted to between Paddys Gully Road and Sara River north-east of Backwater at an elevation of 1220 m.

Extant area: native understorey: 316 ha; exotic understorey: 0 ha; **Total:** 316 ha

Estimated remaining extent of pre-European extent: 95%

Structure: Open forest, trees 12 m high, mid-dense (30–50%) crown cover, with a closed (80%) cover of a tall shrub layer and a very sparse ground cover.

No. native species: 35

No. exotic species: None.

Fig. 31. Community 22 is composed of low open forest of *Eucalyptus radiata* subsp. *sejuncta* and *Eucalyptus caliginosa* with a dense shrub understorey. It is restricted to flats on leucogranite near Kangaroo Gully northeast of Backwater.

Common native species:

- Trees: *Eucalyptus radiata* subsp. *sejuncta*, *Eucalyptus caliginosa*
- Shrubs: *Leptospermum brevipes*, *Leptospermum novae-angliae*, *Mirbelia confertiflora*, *Rhytidosporum procumbens*, *Platysace ericoides*, *Petrophile canescens*, *Hibbertia riparia*, *Acacia buxifolia* subsp. *buxifolia*, *Persoonia cornifolia*, *Cryptandra scortechinii*, *Grevillea scortechinii* subsp. *sarmentosa*
- Ground cover: *Patersonia glabrata*, *Lepidosperma laterale*, *Entolasia stricta*, *Goodenia hederacea* subsp. *hederacea*

Indicator native species: (Only two sites, so illustrative only) *Cryptandra scortechinii*, *Petrophile canescens*, *Hibbertia riparia*, *Acacia buxifolia*, *Rhytidosporum procumbens*, *Hibbertia riparia*, *Choretrum pauciflorum*, *Patersonia glabrata*, *Lepidosperma laterale*

Common exotic species: None.

Variability: Consistent floristics.

Condition: Very good. No weeds and not heavily grazed.

Threats: Too-frequent fire (< 10 year intervals) and bulldozing of fire trails and any future subdivision of portion 14, Parish of Hall are the main threats to this community. While little of this plant community has yet been cleared it is threatened by hobby farming clearing.

Threat status: Guyra: LC(iii); **NSW:** LC(iii)

Reservation code: Guyra: VP; **NSW:** VP

No. reserves in study area containing this community: 0; **Area reserved:** 0

Conservation status: Rare plant community that is not reserved.

Key sites for conservation: Portion 14, Parish of Hall.

Community 23: New England Riparian Shrubland (Fig. 32) (not mapped due to the linear shape of this community)

Equivalent in Hager and Benson (1994): NA; **Forest Type:** NA

Sample sites (15)**:** 32, 39, 43, 49, 98, 127, 141, 218, 232, 241, 252, 271, 276, 281, 296

Landform, substrate and soils: Between or on the banks of watercourses on a range of substrates, growing on alluvial sand-loam or skeletal soils.

Extant area: NA because not mapped

Estimated remaining extent of pre-European extent: 30%

Distribution: Widespread along creeks and rivers in the study area at elevations 1000–1280 m.

Structure: Open to mid-dense tall shrubland often with overhanging trees, with a sparse to mid-dense ground cover.

No. native species: 215; **Mean no. per site:** 36 +/- 12

No. exotic species: 52; **Mean no. per site:** 10 +/- 8

Common native species:

- Trees: *Eucalyptus nova-anglica*, *Eucalyptus pauciflora*
- Shrubs: *Leptospermum polygalifolium* subsp. *transmontanum*, *Rubus parvifolius*, *Hakea microcarpa*
- Ground cover: *Lomandra longifolia*, *Adiantum aethiopicum*, *Epilobium billardierianum* subsp. *cinereum*, *Carex gaudichaudiana*, *Hydrocotyle tripartita*, *Poa labillardieri*, *Myriophyllum variifolium*

Indicator native species: *Leptospermum polygalifolium* subsp. *transmontanum*, *Adiantum aethiopicum*, *Epilobium billardierianum* subsp. *cinereum*, *Carex gaudichaudiana*, *Poa labillardieri*. The threatened *Callitris oblonga* subsp. *parva* occurs along some creeks on leucogranite

Common exotic species: *Hypochaeris radicata*, *Rubus ulmifolius*, *Conyza albida*, *Trifolium repens*, *Centaurium erythraea*, *Holcus lanatus*

Variability: Variation occurs in the structure and floristics depending on the substrate and depth of soil (creek bank compared to rocky river bed). It is a species rich community, as illustrated by 82 species being recorded at site 252 on the Gara River.

Condition: Varies depending on location. Sites on leucogranite on the Sara River are in good condition

Fig. 32. Community 23, riparian shrubland lines watercourses on various substrates. It is often dominated by *Leptospermum polygalifolium* subsp. *transmontanum*. This shows the vulnerable Pygmy Cypress Pine (*Callitris oblonga* subsp. *parva*) growing in Backwater creek.

containing few exotic species, whereas riverine vegetation in more disturbed landscapes contain a greater number of exotic species and are not buffered by adjoining natural vegetation.

Threats: Weed invasion (including blackberry) and pollution and sedimentation of watercourses due to over-clearing in catchments. Susceptible to river mining.

Threat status: NSW: Guyra: E (ii); **NSW** V(ii)

Reservation code: Guyra: VP; **NSW:** M

No. reserves in study area containing this community: 1; **Area reserved:** NA

Conservation status: Probably moderately well reserved or protected on a state and bioregional perspective, although subject to weed invasion. Protected in Warra National Park and along the Sara River in the study area. Riverine vegetation on higher nutrient soils such as basalt are more threatened and not reserved.

Key sites for conservation: Vegetated river courses in the study area, particularly the Sara, Gara and Aberfoyle Rivers. Site 49 at Stuttering Dick's Creek at Backwater contains a remnant stand of *Callitris oblonga* subsp. *parva*.

Community 24: Basalt Plateau Lagoons (Fig. 33)

Equivalent in Hager and Benson (1994): NA; **Forest Type:** NA

Sample sites (6)**:** 45, 47, 277, 278, 311, 312

Landform, substrate and soils: In closed depressions on an undulating, high, mostly basalt plateau with organic soils forming in the lagoons over deep chocolate loam soils. 18 of the 28 lagoons are small — 5 ha in size. Two are 450 ha. Lunettes are present on the eastern shore of some of the lagoons. The lagoons probably formed during the last ice age through the process of deflation, in a similar way to those on the Monaro tableland on the Southern Tablelands of NSW (Benson & Jacobs 1994).

Distribution: Centred on Guyra, on the higher parts of the basalt plateau from Llangothlin in the north to Armidale in the south, at elevations 1310–1350 m.

Extant area: native understorey: 1090 ha; exotic understorey: 0 ha; **Total:** 1090 ha

Estimated remaining extent of pre-European extent: 30%

Structure: Closed to mid-dense sedgeland and grassland on the shores of open water or extending across shallow or dry lagoons.

Fig. 33. Community 24, site 311 at Lagoon Farm is one the few basalt plateau lagoons that has not been drained. These lagoons contain a range of water plants including *Myriophyllum variifolium* (foreground) and the grass *Glyceria australis* (background).

No. native species: 33; **Mean no. per site:** 14 +/- 5

No. exotic species: 8; **Mean no. per site:** 2.3 +/- 1.4

Common native species:

- Trees: None.
- Shrubs: None.
- Ground cover: Water plants, sedges, forbs and grasses are present. *Potamogeton tricarinatus, Myriophyllum variifolium, Nymphoides geminata, Eleocharis acuta, Stellaria angustifolia, Pratia surrepens, Hydrocotyle tripartita, Juncus fockei, Epilobium billardierianum* subsp. *cinereum, Brachyscome radicans, Agrostis avenacea, Glyceria australis*

Indicator native species: *Potamogeton tricarinatus, Myriophyllum variifolium, Nymphoides geminata, Eleocharis acuta, Stellaria angustifolia, Pratia surrepens, Juncus fockei, Hydrocotyle tripartita, Brachyscome radicans, Agrostis avenacea, Glyceria australis, Ranunculus inundatus, Utricularia dichotoma*

Common exotic species: *Holcus lanatus, Juncus articulatus*

Variability: Variable, depending on depth of the lagoon and perhaps other factors. The native grass *Glyceria australis* dominated sites 277 and 278 at Mother of Ducks Lagoon and site 311 Lagoon Farm at the time of the survey, but was less common at other lagoons.

Condition: Those lagoons left undrained are in good condition and retain a variety of water plants, but most of the lagoons in the region have been drained or impounded.

Threats: A vulnerable plant community because most of the 28 lagoons that once existed in the study area (D. Bell pers. comm.) have been drained or impounded. Disrupted hydrology remains the main threat to the lagoons not protected in reserves. Grazing, agricultural pollution and uncontrolled recreational use may also threaten the vegetation.

Threat status: Guyra: E(ii); **NSW:** E(ii)

Reservation code: Guyra: P; **NSW:** P

No. reserves in study area containing this community: 2; **Area reserved:** 208 ha

Conservation status: Little Llangothlin and Mother of Ducks Nature Reserves protect sections of two of the lagoons.

Key sites for conservation: All remaining undrained lagoons should be protected and some previously drained ones could be restored. Site 311 at Lagoon Farm near Black Mountain is a key site for protection. This lagoon along with the surrounding Snow Gum woodland should be protected as a nature reserve or under a conservation agreement with the landholder.

Reservation status and sites of botanical significance

Table 4 lists the area and proportion of existing extent (based on 1989 aerial photographs) of each plant community in reserves in the study area. Only 0.72% of the study area is reserved. None of the 24 plant communities are currently adequately conserved, using the definitions of Hager and Benson (1994) or JANIS (1996). This is not surprising given that 74% of the vegetation has been cleared and only five small conservation reserves have been established. The proportion of cleared land is higher than for other parts of the New England Bioregion (Fig. 34), probably because a large part of the study area is composed of basalt-derived soil and undulating topography.

Table 5 lists the most significant locations for conservation. These have been selected based on the criteria of representativeness of a plant community, condition, size, the presence of rare, threatened or other significant species. These locations include publicly owned land including conservation reserves, roadsides and travelling stock reserves as well as private land.

Backwater

The most significant area for conservation is the leucogranite vegetation remnant near Backwater. Most of this is private land, but it includes public land along the Sara River and in Warra National Park. This is the largest intact vegetation remnant in the study area (Fig. 35) and contains the highest number of plant communities and rare plant species. Most of the communities on this leucogranite outcrop are in good condition, although some land clearing was occurring during the time of survey. Further clearing could threaten some of these communities.

The most critical portions of land for conservation in this area are portion 14, Parish of Hall, County of Clarke and the adjoining eastern vegetated part of portion 54, Parish of Coventry, County of Clarke on the property 'Wattleridge'. These areas contain eight of the 24 plant communities defined in this survey (communities 10, 11, 12, 15, 17, 20, 21, 22 and 23). The rare or threatened plant species *Callitris oblonga* subsp. *parva*, *Eucalyptus codonocarpa*, *Grevillea scortechinii* subsp. *sarmentosa*, *Persoonia procumbens*, *Eucalyptus camphora* subsp. *relicta*, *Daviesia elliptica*, *Muehlenbeckia costata*, *Monotaxis macrophylla*, *Thelionema grande*, *Leionema ambiens*, *Acacia brunioides* subsp. *brunioides* and *Pseudanthus divaricatissimus* are present on the leucogranite outcrop north and south of the Sara River.

On the northern side of the Sara River the Warra National Park was declared in 1999. It was previously part of Warra State Forest. The NSW National Parks and Wildlife Service has a national park proposal over the vegetated lands on the southern side of the Sara River including portion 14, Parish of Hall, and the eastern part of the property 'Wattleridge'. This land remains in private ownership but 'Wattleridge' has recently been purchased by the Guyra Aboriginal Land Council. Until this land is managed for conservation, hobby farm subdivision and development may threaten the integrity of the vegetation and compromise Warra National Park.

Table 4: Area, threat and reservation status of the vegetation communities on Guyra 1: 100 000 sheet.

Plant Community	Estimated pre-European extent (ha) (approx.)	Estimated original rarity in NSW	Remaining extent (ha) (% pre-European extent)	Threat Status for study area	Area in reserves (ha) in study areas	% pre-European extent reserved	Reservation status for study area
1. *E. blakelyi-E. melliodora* Open Forest	33 000	Common	6612 (20)	E	1	0.003	VP
2. *E. caliginosa* Open Forest	17 000	Common	11 146 (65)	LC	443	2.4	P
3. *E. laevopinea* Open Forest	20 000	Common	10 084 (50)	NT	373	1.5	P
4. *E. banksii-E. laevopinea* Open Forest	500	Restricted	337 (70)	NT	13	2.7	P
5. *E. youmanii-E. andrewsii-E. nicholii-E. subtilior* Open Forest	22 000	Common	3330 (15)	E	0	0	VP
6. *E. viminalis-E. dalrympleana-E. pauciflora* Open -Tall Open Forest with a Grassy Understorey on basalt	44 500	Common	6643 (15)	E	17	0.04	VP
7. *E. stellulata-E. pauciflora* Low Open Forest or Low Open Woodland with a grassy understorey	18 000	Common	1819 (10)	E	27	0.15	VP
8. *E. nova-anglica* Woodland on basalt	7000	Common	345 (5)	CE	0	0	VP
9. *E. nova-anglica* Woodland on sediments	13 000	Common	1979 (15)	E	54	0.4	VP
10. *E. nova-anglica-E. pauciflora* Open Forest on granite and leucogranite	18 000	Common	4458 (25)	E	2	0.01	VP
11. *E. caliginosa-E. dalrympleana* Open Forest on leucogranite	7300	Common	4397 (60)	NT	56	0.76	VP
12. *E. campanulata* Open Forest on leucogranite	2500	Restricted	2118 (90)	LC	126	5.36	M
13. E. laevopinea-E. nobilis Open Forest on sediments	3000	Common	923 (30)	V	0	0	VP

Plant Community	Estimated pre-European extent (ha) (approx.)	Estimated original rarity in NSW	Remaining extent (ha) (% pre-European extent)	Threat Status for study area	Area in reserves (ha) in study areas	% pre-European extent reserved	Reservation status for study area
14. *E. radiata-E. nobilis-Hovea* sp. A Open Closed Forest	600	Rare	512 (90)	LC	0	0	VP
15. *E. nobilis-E. caliginosa* Open Forest on leucogranite	1400	Restricted	811 (60)	NT	115	8	M
16. *E. caliginosa-E. nobilis-E. blakelyi* Open Forest, Oban River	1700	Restricted	825 (50)	V	0	0	VP
17. *E. obliqua-E. nobilis* Tall Open Forest	3600	Common	2893 (80)	LC	179	5	M
18. *E. radiata-E. acaciiformis* Open Forest on granite	17 600	Common	7061 (40)	V	0	0	VP
19. *E. acaciiformis-E. caliginosa-E. radiata* Low Open Forest on sediments	2500	Restricted	509 (20)	E	0	0	VP
20. Heath Swamps on leucogranite and granite	500	Restricted	369 (80)	LC	15	3.26	P
21. *E. codonocarpa* and heath on rocky outcrops on leucogranite	250	Rare	241 (95)	LC	4	1.6	P
22. *E. radiata-E. caliginosa* Open Forest with dense shrubland on leucogranite	330	Rare	316 (95)	LC	0	0	VP
23. New England Riparian Shrubland	NA	Restricted	NA	E	NA	NA	VP
24. Basalt Plateau Lagoons	3000	Restricted	1000 (30)	E	208	7.00	M

Remaining extent is calculated from the GIS, while pre-European extent is estimated. The five conservation reserves in the study area also contain 271 ha of cleared land. Area of basalt lagoons (community 24) is inflated due to size of impoundment of Llanglothlin Lagoon. 'Original Rarity' is used to help define threat status. It refers to an estimation of the pre-European extent of the plant community in Australia: Common > 10 000 ha, Restricted 1 000 to 10 000 ha, and Rare < 1000 ha. The threat categories are based on IUCN (1999): CE = critically endangered, E = endangered, V = vulnerable, NT = near threatened, LC = least concern. Application of the threat codes is based on the proportion of the remaining extent to estimated pre-European extent (see text). Reservation codes are calculated by comparing extent reserved with the estimated pre-European extent in the study area: VP = very poor (< 1%), P = poor (1–5%), M = moderately well conserved (5–10%), AC = adequately conserved (10–25%), EC = exceptionally well conserved (> 25%). Riparian vegetation (community 23) was not mapped but threat and reservation estimates are provided. The extent of pre-European natural grasslands is also not included.

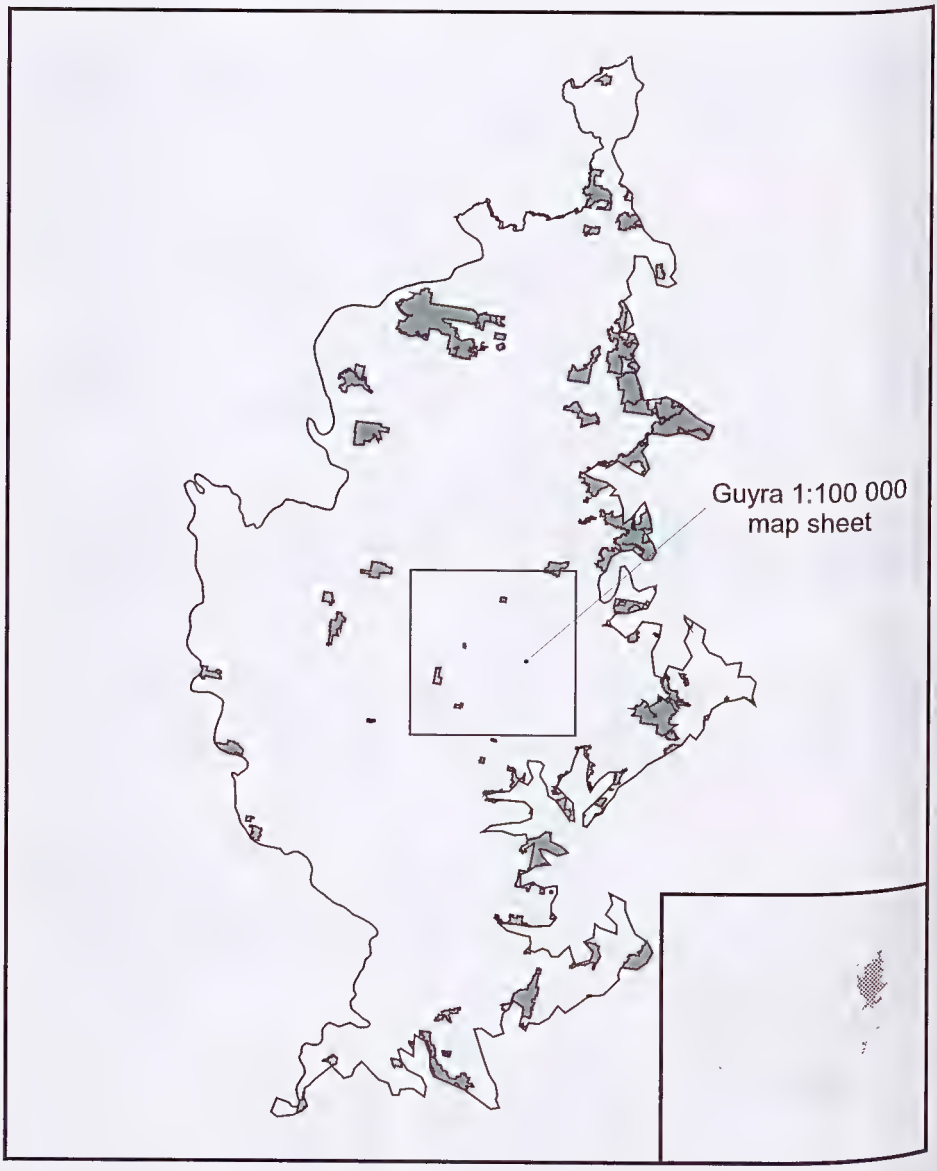

Fig. 34. Distribution of conservation reserves in the New England Tableland Bioregion. Only 0.72% of the study area is reserved compared to 7.5% for the Bioregion as a whole (data from NSW NPWS).

Table 5: Sites of botanical significance in the Guyra 1:100 000 map sheet area.

Justification criteria: T = contains rare or threatened plant species; S = contains plant species of regional significance; C = is in relatively good condition; M = is well fenced or easy to manage in other ways; D = contains high diversity of plant species; R = outstanding example of a plant community.

Locations or sites	Comm.	Location	Justification
Mother of Ducks Lagoon Nature Reserve	24	Mother of Ducks Lagoon, Guyra	T C M R
Little Llangothlin Nature Reserve	24, 6	Little Llangothlin Lagoon, Guyra	T C M R RAMSAR site
Boorolong Nature Reserve	2,3,4	North-west of Armidale	C M R
Mount Duval Nature Reserve	2,3,17	Mount Duval north of Armidale	C M D R
Warra National Park and Warra State Forest	10, 11, 12, 15, 17, 20, 21, 23	Sara River on leucogranite north of Backwater	T S C M D R
Portion 14 and Wattleridge and Sara River reserve.	10, 11, 12, 15, 17, 20, 21, 23	North of Backwater	T S C M D R
Parts of Days Ridge	2, 17, 18	20 km N/E of Guyra	C D R
Lagoon at 'Lagoon Farm' and adjoining ridge	24, 6	Black Mountain	C M D R
Avondale State Forest	13	Rockvale Rd east of Armidale	C M R
Mount Nobbler: sites 162, 163, 164	14, 17	North of Backwater	S C D R
6, 7	6	TSR New England Hwy Guyra	C R
10	6	Crown Reserve Ben Lomond	C M R
12, 13	5	Wandsworth Rd	T C R
14	5	TSR Tingha Rd	T C R
15, 191	9	Tingha Rd	C R
21	18	Wards Mistake Rd	C M D R
22	10	Wards Mistake Rd	C R
28, 113	1, 3	Thunderbolts Cave TSR	T C M D R
49	23	Stuttering Dicks Ck Backwater	T
67	9	Rockvale Rd	C R
80	4	Sunnyside Rd	S C M R
82	1	P 55 Thalgarrah	C R
84	1	Rockvale Rd TSR	S C M R
92	2	Eastview Rd	C R
93	9	Rockvale Rd Wollomombi River	C R
95	19	Rockvale Rd	C R
143	10	Oban River	C R
155	6	Baldersleigh Rd	T
175	2	Wandsworth Rd	C R
177	5	Happy Valley	T C R
180,181,182	5	Roadside reserves Aberfoyle Rd	T C D R
186, 187	6	New England Hwy TSR Ben Lomond Range	M C R
213	2	Little Duval	C R

Locations or sites	Comm.	Location	Justification
215	5	Wychwood near Fleetwood	T C M D
221	5	Old Armidale Rd	S C D R
223	1	Old Armidale Rd	C R
235	10	Granite Springs Oban River	R C S
268	18	near Beesnest Hill	T R
273	18	Stonebrook	C R
287, 288	5	west of Reedy Creek HS	S C D R
299, 306	4	Abington Ck	C R
309	2	Caer Timvil	C R

Avondale State Forest

Although the state forests in the area are not specifically reserved for conservation, they afford some protection to a number of plant communities (except for Armidale State Forest, which is pine plantation). Avondale State Forest contains stands of community 13 which is otherwise not protected on public land.

Days Ridge

This is located in the central-eastern section of the map sheet and contains remnant forests of *Eucalyptus obliqua-Eucalyptus nobilis* (community 17) and *Eucalyptus radiata* subsp. *sejuncta* (community 18). It is mainly private land and parts of it have been substantially logged.

Fig. 35. The largest vegetation remnant in the study area occurs on the leucogranite outcrop north-east of Backwater. This is a key area for conservation because it contains a rich species diversity, a number of rare plant species and a variety of plant communities.

Mount Nobbler

Located three km north-west of Backwater, this granite mountain contains some outstanding stands of community 17, *Eucalyptus obliqua-Eucalyptus nobilis* on protected slopes and community 14 *Eucalyptus radiata-Eucalyptus nobilis-Hovea* sp. A. Some of the footslopes have been recently cleared, even though the ground is rocky.

Happy Valley-Whans Road

The vegetation remnants in this area contained stands of the vulnerable species *Eucalyptus nicholii* and *Eucalyptus youmanii* in community 5 (for example, site 177). Most of this community has been cleared and recent clearing was noted during the survey. *Eucalyptus nicholii* also occurs in a stand of stringybark forest at site 215 west of Boorolong.

Reedy Creek

A stand of *Eucalyptus andrewsii*, *Eucalyptus prava* and *Eucalyptus laevopinea* is present west of Reedy Creek homestead on the steep, rocky hills on an acid volcanic substrate. This has been classified into community 5, although it could be separated from it. While it is restricted in the study area, it is more common to the west.

Travelling stock reserves and roadside reserves

Some of the most important vegetation remnants, containing vegetation that have not been continuously grazed, are located on TSRs or roadsides. These include TSRs along the New England Highway, Rockvale Road, Aberfoyle Road and the Guyra-Tingha Road. The dominant plant species on these TSRs and some sites of conservation significance are documented in Williams and Metcalfe (1991).

An important TSR is Thunderbolts Cave TSR at the Devils Pinch off the New England Highway. This contains a stand of community 1 (site 113) with *Eucalyptus youmanii* and *Pultenaea campbellii*, and regrowth community 3 with a rich diversity of species (site 28). One of the best examples of community 6 (Mountain Gum-Ribbon Gum on basalt) is in the Ebor and Aberfoyle road reserves near the Aberfoyle River (sites 180, 181 and 182). A good patch of community 6 is also found in a crown reserve (site 10) along Wandsworth Road, 3 km south-west of Ben Lomond.

Basalt lagoons

Two small nature reserves (Mother of Ducks and Little Llangothlin) protect parts of two lagoons on basalt (community 24). Little Llangothlin Nature Reserve is listed on RAMSAR as a wetland of international significance. Wetland vegetation of these lagoons remain inadequately reserved and vulnerable. Protection of the wetland on the property Lagoon Farm (site 311) would improve the conservation status of community 24.

Sites with regionally uncommon species

Some sites are important because they contain species that are restricted in their abundance in the study area. Examples include site 87 (Rockvale Road TSR) that contained a tableland occurrence of Grey Box *Eucalyptus moluccana*; sites 80 (Sunnyside Road) and 306 (Little Duval) contained a tufted grassy understorey dominated by the grass *Joycea pallida* and site 221 along the Old Armidale Road that contained the only record for the sedge *Caustis pentandra* in the survey. The recording of the ground orchid, *Caladenia cucullata* at site 133 on 'Wattleridge' was an extension of range for that species.

Other sites included important samples of a community and unusual species. For example, site 235 near the Oban River contained one of the few large stands of *Eucalyptus nova-anglica* encountered during the survey, as well as a northern extension of the grass *Poa clivicola*. Given the impacts of clearing and dieback on communities 8, 9 and 10, any reasonable remnants should be protected.

Discussion

The remaining natural vegetation on the Guyra map sheet is a composite of various sized remnants with different degrees of human-induced disturbance. Overall, the vegetation is a mosaic of grassy open forest and woodland, shrubby open forest, heaths, swamps and lagoons. The distribution of these major types of vegetation is largely determined by physiographic determinants — a combination of parent material and climatic factors. At a finer scale, local site elements such as topography and disturbance history play a modifying role. The largest and most 'natural' remnants occur on the poorest soils and roughest topography including the leucogranite country near Backwater. Most remnants on medium to high nutrient soils are moderately or severely disturbed, at least in their understorey. The tree canopies of plant communities 1–3, 6–10 and 18–19 are, in most cases, composed of secondary regrowth from episodes of clearing in the early 20th and late 19th centuries (Curtis 1989).

Sampling methods

Standards of vegetation survey are discussed in Benson (1995) and Keith and Bedward (1999). It is important that users of vegetation plot data or vegetation maps be aware of the rules that formed the basis of the gathering and interpretation of the data. Scale is one factor that can alter the intensity of survey and detail of mapping.

The vegetation of the study area was sampled on the basis of stratifying the environmental variables of substrate, altitude and landform position. While inspections of rainfall and temperature maps on the NSW National Parks and Wildlife Service geographical information system indicated that rainfall and temperature broadly corresponds to altitude, there are some inconsistencies. For example, there is a marked rainshadow in the south-eastern corner of the study area near Bakers Creek and this variation was not taken into account in stratifying the sampling. It is likely there are inaccuracies in the geology mapping for the region therefore confounding

some of the assumptions about sampling major nutrient classes. Also, some plant communities were under-sampled due to the limitations of the LANDSAT-derived vegetation cover GIS layer (Roberts 1992) that was used in selecting sample sites. It identified forest or woodland with a canopy cover of greater than 20%. Therefore, scattered open woodland vegetation, including patches of New England Peppermint *Eucalyptus nova-anglica* (communities 8, 9 and 10), Ribbon Gum *Eucalyptus viminalis* (community 6), and small remnants of less than 5 hectares in area, were not mapped from the LANDSAT image. Although we modified the sampling design to cater for these deficiencies, open vegetation may still have been undersampled. An example is that the small remnants of community 6 were under-sampled in the southern part of the study area. Finally, vegetation remnants in areas distant from roads or tracks were less well sampled than vegetation near roads or tracks.

Classifications of vegetation through numerical analysis can be achieved by either sampling all species in plots or a subset of them. Recording all species takes more time than recording a subset of species. Alternatively, if the aim is to model certain species across a landscape there is advantage in maximising the number of sample plots by minimising the time to sample them ie. by recording a subset of species. Austin et al. (1999) used this strategy in modelling the pre-European distribution of tree and tall shrub species (> 1.5 m) in a survey of the Lachlan region in the NSW wheatbelt.

We recorded all species in plots because we considered that there were benefits of recording full floristic data. Only through the latter can relative rarity be assessed for the total vascular flora of a region. Also, the presence or absence of ground cover and shrub species can be important in determining floristic groupings in a numerical classification. Understorey species should not be underestimated when classifying vegetation.

Mapping scale

The selection of scale depends on the purpose but scale can have major implications for selecting units in the landscape for decision making (Pressey & Logan 1995). We mapped the vegetation of the Guyra 100 000 map sheet area at 1: 25 000 scale. This is a relatively fine scale for regional mapping (Benson 1995), but it was chosen to adequately represent the complexity of the patterns of vegetation, the small size of many vegetation remnants, and the size of properties in the Bioregion. This also matches the topographic map and aerial photographic coverage for the region.

The accompanying published Guyra vegetation map is at 1: 100 000 scale. Such a reduction in scale can lead to a loss of definition of vegetation remnants, and also an amalgamation of floristically classified polygons leading to increased heterogeneity of map units. While these simplifications have been minimised in the published map, vegetation assessments and planning should use the 1: 25 000 scale GIS version of the map. This provides a capacity for generating different map products because each polygon has multiple attributes (viz. type of vegetation, structure, degree of disturbance and understorey condition). Map coverages could be generated, for example, showing the distribution of exotic versus native understorey within certain targeted plant communities.

Plant community classification

Austin and Smith (1989) point out that the community concept of co-occurring species is most relevant to a particular landscape, or region, reflecting its patterns of environmental variables. This highlights the danger of applying a broad-based typology such as 'forest types' (Forestry Commission of NSW 1989) in describing or assessing vegetation in a local or regional context. Most of the 'forest types' that we intuitively attempted to match the plant communities to are much broader in their coverage of geographical distribution and botanical variation.

Understorey variation due to varying degrees of disturbance caused considerable noise in the UPGMA, data output. Some sites were placed into groups counter to intuition because of this variation. The nearest neighbour analysis helped to correct some of these apparent anomalies. This understorey variation caused by different histories of grazing in particular, highlights one limitation of using full floristic plot data to derive vegetation classifications in agricultural landscapes, compared to using it to classify vegetation in more natural landscapes such as conservation reserves. However, when a subset of the floristic data containing only tree species were subjected to UPGMA, the resulting classification was considered to be too simplistic.

The scope of a classification can be important in defining the number of plant communities. Our survey sampled all of the major formations of vegetation across the landscape. We classified one type of heath/mallee (community 21) growing on leucogranite outcrops near Backwater. In contrast, Hunter and Clarke (1998), who restricted their flora survey to vegetation on granitic outcrops in the New England Bioregion, defined three floristic groups on outcrops in the Backwater area.

Patch size also affects the recognition of plant community types. Hunter and Clarke (1998) defined a closed scrub community dominated by *Quintinia sieberi* and *Rapanea* spp. as occurring among leucogranite rock outcrops protected from frequent fire. We only observed this community once and due to its rarity and patch size relative to the scale of the work, it was not sampled nor mapped.

Limited sampling can also affect community classification. For example, an open forest dominated by *Eucalyptus prava* and *Eucalyptus andrewsii* occurs on acid volcanic ridges in a remnant on the western edge of the map sheet (sites 287–289). *Eucalyptus prava* is more common to the west and north-west of the map sheet. It is a canopy co-dominant of plant communities in Torrington State Recreation Area (Clarke et al. 1998) and in Kings Plain National Park (Hunter 2000).

Based on shared understorey species, our sampling grouped this forest into the western tableland stringybark-dominated plant community 5 which is dominated by *Eucalyptus youmanii, Eucalyptus andrewsii* and *Eucalpytus subtilior*. It is likely that with more sampling to the west a new plant community would be defined, including the *Eucalyptus prava/Eucalyptus andrewsii* sites 287–289.

Species patterns

Over 150 years of grazing, pasture improvement and clearing of forests has altered the species composition of the vegetation. This has particularly affected plant communities 1, 2, 3, 6, 7, 8, 9 and 19 which occur on high to medium nutrient soils and contain a grassy ground cover.

A number of upright perennial forbs occurring in these communities are regionally rare including *Eryngium ovinum*, *Eryngium vesiculosum*, *Podolepis jaceoides*, *Podolepis neglecta*, *Microseris lanceolata*, *Swainsona monticola*, *Geranium retrorsum* and *Velleia paradoxa*. Tremont (1994) found that tall herbacous plants are susceptible to being grazed out compared to low forbs with flat rosettes. She demonstrated that grazed treatments favoured annual species with reproductive organs at or near ground level between dominant tussocky grasses. Our survey demonstrated that prostrate-leaved forbs such as the introduced *Hypochaeris radicata* or the native *Cymbonotus lawsonianus* were common.

Most species were recorded a few times only. This pattern is similar to that documented in McIntyre et al. (1993) for herbaceous species in the Bioregion. McIntyre (1992) suggests that sparse species occurring in grassy woodlands or in derived native grasslands have been overlooked in threatened species listings. The redlist criteria developed by IUCN (1994) (under revision IUCN 1999) overcomes this to some extent, as susceptible species can be identified if they are declining.

The ubiquitous stringybark communities 2 and 3 are the most widespread plant communities in the study area. Both stringybark species *Eucalyptus caliginosa* and *Eucalyptus laevopinea* occur on various substrates and aspects but both species tend to grow on ridges or slopes rather than in valley bottoms. Since hybridisation between these species may occur, it is difficult to detect clear patterns in their distribution. Significant differences of distribution occur due to substrate and aspects. Broad-leaved Stringybark, *Eucalyptus caliginosa*, is widespread on siliceous sedimentary substrates in the south around Armidale, on siliceous acid volcanic substrate in the north-west of the study area, on granite and on leucogranite north of Backwater as a co-dominant in quite different floristic assemblages from those on sediments and acid volcanics. Silver-topped Stringybark, *Eucalyptus laevopinea*, tends to occur on steep, well drained, protected (south or east facing) slopes (sometimes enriched by basalt above). It also commonly occurs on acid volcanic, sedimentary and basaltic substrates but is less common on leucogranite and granite.

The databased survey data provides a basis for further analysis of species patterns and modelling of species distribution.

Modifications induced by European land use

A thorough account of the changes to the vegetation on the Northern Tablelands since European settlement is given in Curtis (1989), although much of his discussion deals with regions outside the Guyra 1: 100 000 map sheet study area.

Clearing, grazing and soil erosion

As early as the 1870s people were alarmed at the effect of clearing on the landscape. Mrs Charles Meredith (1844), referring to clearing near Sydney, wrote:

'The system of clearing here by the total destruction of every tree and shrub gives a most bare, raw and ugly appearance to a new place'.

Today, approximately 26% of the native tree cover remains in the study area. Much of this is regrowth forest after past clearing or logging (Nadolny 1995). Clearing has concentrated on the more fertile soils and flatter terrain. Relatively intact plant communities are 12, 13, 14, 15, 17, 20, 21 and 22. Most of these are confined to poor soils on leucogranite in the Backwater region. However, clearing of marginal agricultural lands on granite and leucogranite for hobby farms has continued up to the present.

The communities on higher nutrient soils (1, 3, 6, 7, 8, 9, 10, 19) are mostly cleared and remain as small remnants. The NSW land cover study by ERIC (1998) revealed that very little clearing (50 ha/year) took place in the study area between 1995–97. This was possibly due to low commodity prices for wool and meat.

Some communities are estimated to have been cleared to less than 20% of their original extent, for example Blakely's Red Gum-Yellow Box on sediments (community 1), Mountain Gum-Ribbon Gum on the Guyra basalt plateau (community 6), and communities 8 and 9 containing New England Peppermint. Furthermore, communities 1, 2, 8, 9, 10 and 18 have been extensively ringbarked in the past (Fig. 36) and affected by dieback.

Over-clearing and subsequent over-grazing has led to soil erosion in some places (Fig. 37). Gale et al. (1997) found that the deposition rate of soil into Llangothlin Lagoon accelerated after the introduction of stock by Europeans in the Guyra area in 1837. These authors postulate that much of the topsoil of the lagoon's catchment was eroded within 25 years of the arrival of Europeans.

Continuous grazing of most grassy woodland or forest remnants (communities 1, 2, 3, 6–10 & 19) has probably led to a depletion of the shrub understorey and a lack of regeneration of trees (Curtis 1989). Norton (1876) noted patches of wattle (*Acacia*) among white gums (*Eucalyptus viminalis* or *E. pauciflora*) and New England Peppermint near Glen Innes in the 1850s, and the Government botanist (Maiden 1898) noted *Acacia* as being common in the understorey in the region. During our survey wattle was rarely abundant in sample plots in the grassy woodland communities — although it was more common on roadsides or in travelling stock reserves that are not continuously grazed. Overall, wattle appears to have declined substantially since European settlement.

Many native grass and forb species have declined under high grazing pressure because of their growth habit or palatability. In extreme cases the natural ground cover has been completely altered through ploughing and sowing of exotic species creating an appearance of a manicured park (Fig. 38). Both Whalley et al. (1978) and McIntyre et al. (1993) report that stock grazing has produced a shift from tall tussocky grass species, such as *Themeda australis* and *Sorghum leiocladum*, to more prostrate, shorter

Fig. 36. Large areas for forest on the New England Tableland Bioregion have been ringbarked such as this stand of *Eucalyptus nova-anglica-Eucalyptus pauciflora* open forest (community 10) north of Backwater.

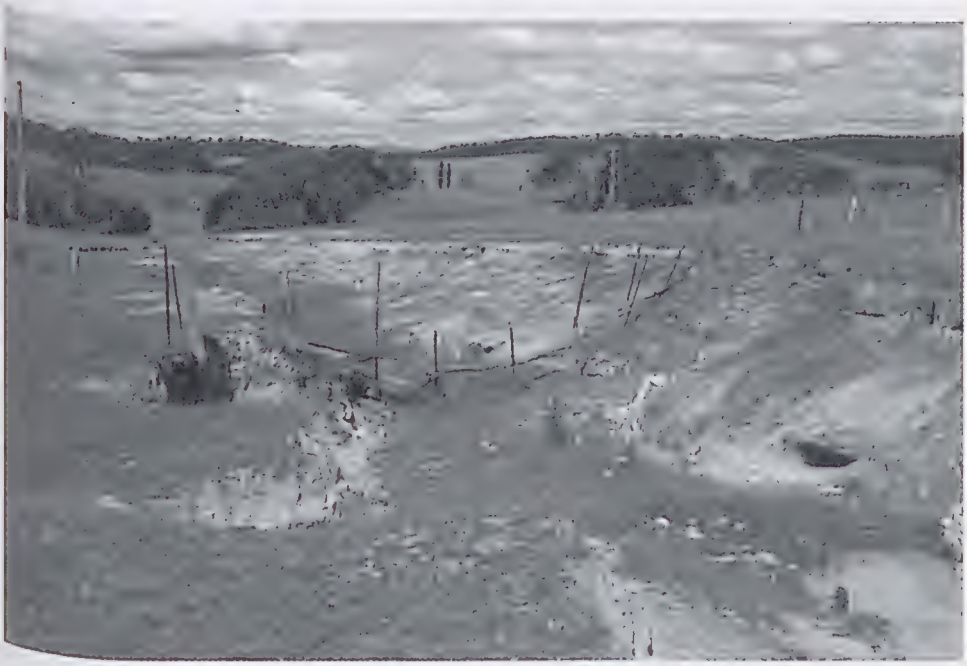

Fig. 37. Clearing of native vegetation followed by heavy grazing has led to gully erosion in some places such as this gully at the foot of Mount Hourigan.

Fig. 38. The ground cover in many forest remnants has been replaced by exotic species. This is illustrated here in this *Eucalyptus laevopinea* forest on basalt north-west of Armidale where the ground cover is dominated by the exotic grasses *Hordeum leporinum, Lolium perenne* and *Bromus* spp.

species. They note that less palatable native grasses such as *Poa sieberiana* may increase in the presence of grazing and the removal of competitors. Our survey data support this view as *Poa sieberiana* was the most common species recorded in the 312 sample plots.

Fragmentation

Clearing of two thirds of the woody vegetation along with episodes of dieback have yielded a fragmented landscape. However, the degree of fragmentation is generally less pronounced than that in the Western Australian and eastern Australian wheatbelts (see papers in Saunders et al. 1987). Studies on fragmentation show that when 50% of vegetation is cleared, connectivity between remnants is broken (Dawson 1994). When more than 70% of a landscape is cleared, the small patches of bush between larger remnants tend to disappear (Andren 1994). This leads to a significant decline in the population of some species because their dispersability across the landscape diminishes as distance between remnants increases (Andren 1994, Schwartz 1992).

The theory of island biogeography of species diversity in relation to habitat area and spatial arrangement of habitats (MacArthur & Wilson 1967) is more applicable when the matrix between habitat patches is distinct (Diamond 1981). It is postulated that habitat sensitive plant or animal species will not persist or cross altered countryside (Dawson 1994). However, some less sensitive species will. Native pasture and isolated trees commonly occur between vegetation remnants in the New England Bioregion. For this reason McIntyre and Barrett (1992) described the Bioregion as a variegated landscape because diffuse boundaries exist between forest remnants and pasture land

compared to the sharp boundaries encountered in crop lands or on oceanic islands. However, since we did not map native pastures or isolated clumps of trees less than one hectare in size, any use of the vegetation map for predicting the impacts of fragmentation on certain species need to take these limitations into account.

Assuming that some native species live in substantially modified habitats, vegetation management should not be restricted to preserving large remnants. Rather, the whole landscape should be managed sympathetically. Nevertheless, it is likely that species of animals and plants with low populations, low reproductive potential, poor dispersal mechanisms and large fluctuations in their populations would be most susceptible to extinctions in the most fragmented parts of the study area. These would include areas covered by communities 1, 5, 6, 7, 8, 9, 10, and 19 which have been reduced to less than 30% of their pre-clearing extent.

In a study of vegetation remnants near Armidale, Barrett et al. (1994) found that 104 of the 137 bird species recorded were threatened by fragmentation and structural change of the vegetation. Some bird species such as the Red-browed Treecreeper were restricted to large (> 400 ha) remnants, while other species were recorded in smaller remnants. Reid (1999) supported these findings for woodland bird species occurring on the Southern Tablelands of NSW. He found that size, complexity and spatial arrangement of vegetation remnants are critical factors for the survival of many woodland birds. Barrett et al. (1994) concluded that to protect what is left of the New England avifauna, vegetation remnants of various sizes need to be maintained, a range of tree age classes need to be present, and the understorey needs to be managed to encourage regrowth of shrubs. This may require the judicious use of fire to stimulate the germination of some shrubs species and controlling stock numbers to allow for their growth to maturity.

Enhancing corridors may allow species to recolonise areas through immigration (Diamond & May 1976) where stochastic events (fire, drought, flood, changes in herbivory or predation) may have led to their localised extinction.

Weeds

Invasive plants are not as critical a threat to native vegetation in the study area compared with other parts of eastern Australia. There are numerous pasture weed species. Some of these dominate the ground cover and invade forest remnants that adjoin pastures. Only a small proportion of the 146 exotic species recorded are 'problem' weeds. *Hypochaeris radicata* was the most commonly recorded exotic species.

The long lived shrub, Hawthorne (*Crataegus monogyna*), is a weed in some places — particularly near Armidale. The fruit of this species is dispersed by birds such as the Pied Currawong (Bass 1989). Privet (*Ligustrum vulgare)* has seeded into forest remnants close to settlements but is less abundant than Hawthorne. Blackberry (*Rubus ulmifolius*) invades riverine vegetation (community 23) by dispersing along watercourses. St John's Wort (*Hypericum perforatum)* is common in some disturbed pastures and forests such at site 29 along Sunnyside Road north of Armidale. Although we did not record African Love Grass *(Eragrostis curvula)*, it is present and

increasing in abundance in the Bioregion (C. Nadolny pers. comm.). It is becoming a major weed species in other places such as western Sydney and on the Southern Tablelands. Both *Hypericum perforatum* and *Eragrostis curvula* produce large quantities of small dispersible seeds and therefore may easily increase in abundance.

Dieback

Dieback is a complex phenomenon that has caused the death of millions of trees in rural areas of south-eastern Australia (Landsberg & Wylie 1988). The Northern Tablelands gained national attention in the late 1970s and 1980s due to a major episode of dieback that killed millions of trees (Nadolny 1988). Several studies on dieback have concentrated on the Northern Tablelands (for example Williams & Nadolny 1981, Mackay et al. 1984, Jones et al. 1990). Nadolny (1995) summarised the current viewpoints about the causes of dieback in the region:

- Defoliation by scarab beetles was a major cause of dieback on the Northern Tablelands in the 1970s–80s. It is postulated these beetles may have increased in numbers due to a combination of favourable climatic conditions, the existence of more feed for their larval stage in improved pasture, reduced predators such as birds, bandicoots and parasitic wasps and an increase in the nutrition of the foliage of trees due to livestock excrement and fertilizer;
- Drought can cause water stress in trees making them more susceptible to infections (White 1986);
- Fungal infections can occur in trees damaged by storms. Isolated trees in paddocks are more susceptible to storm damage;
- Increased soil salinity and water stress during drought.

In the study area dieback has most affected:

- Community 1: *Eucalyptus blakelyi-Eucalyptus melliodora* open forest on sediments around Armidale;
- Community 2: *Eucalyptus caliginosa* open forest in remnants east of Armidale along the Chandler Road. In other places stringybark trees were little affected by dieback;
- Community 8: *Eucalyptus nova-anglica* open forest on basalt (Fig. 18);
- Community 9: *Eucalyptus nova-anglica* open forest on sediments around Armidale and Boorolong. This has been the most affected community with whole valleys losing all of their trees (Williams & Nadolny 1981, Nadolny 1988);
- Community 10: *Eucalyptus nova-anglica-Eucalyptus pauciflora* woodland on granite and leucogranite near Backwater and along the Oban River;
- Community 18: *Eucalyptus radiata* subsp. *sejuncta-Eucalyptus acaciiformis* open forest on granite near Llangothlin, Rockvale Road, Days Trig and Wards Mistake.

Logging

Even where the vegetation has survived the initial phases of land clearing, continued logging has altered the structure of the forest and now few old trees remain. This is evident in state forests and on private forested land. Logging has particularly had an impact on communities 2, 3, 13 and 17. A recent trend towards wood heating in Armidale has led to increased cutting of trees for firewood and a resource depletion

Fig. 39. Subdivision and road construction on non-agricultural private land is threatening some of the largest vegetation remnants in the study area, such as this *Eucalyptus radiata* subsp. *sejuncta*-*Eucalyptus nobilis* (community 15) forest on leucogranite near site 34 at Mount Mitchell north of the Sara River.

(Wall & Reid 1993). This is impacting on plant communities that contain poor sawlog timber that had not previously been subject to sawlog extraction. An example of this is community 5 that occurs on acid volcanic substrates on the drier, western side of the study area.

Subdivision

One of the main threats to some of the larger vegetation remnants on rougher terrain composed of granite, acid volcanic or leucogranite substrates is subdivision for hobby farms. Areas around Mount Mitchell have been subdivided into 25 and 100 ha blocks with wide roads being pushed through some of the largest vegetation remnants in the study area (Fig. 39). The owners of these small bush blocks often clear part or all of them and introduce stock and other domestic animals. In contrast, some subdivision within a 20 km radius of Armidale may be having a positive effect on regeneration of plant communities 1, 2, 3 and 9 because grazing has been removed or limited.

Draining wetlands

Draining or impounding of lagoons has severely depleted the abundance of the wetland plant community 24. This could be considered a vulnerable plant community. Assessments by D. Bell (pers. comm.) reveal that only six of an original estimated 30 swamps in the study area remain in good condition. Most of these swamps occurred on the basalt plateau near Guyra, with a few near Armidale. Most have been

drained for conversion to pasture, some have been impounded to form dams for stock. One of the best remaining wetlands is Lagoon Farm near Black Mountain (Fig. 33). This wetland, along with the surrounding Snowgum woodland, ranks as one of the highest priority areas for conservation in the study area.

Changed fire regimes

Due to the degree of modification of the landscape, and a lack of documentation of past fires or Aboriginal burning practices, it is not possible to decipher precisely what were the pre-European fire regimes in the different plant communities in the study area. Presumably, moister forests with shrubby understoreys (for example, communities 17 and 18) would not have been subject to frequent fires. Some of the shrublands and dry sclerophyll forests on acid volcanic and leucogranite substrates may have been subjected to intense fires every 10–30 years. The grassy woodland communities may have been subjected to a mosaic pattern of less intense and relatively frequent burning by Aborigines.

Some plant species in the small, isolated remnants may have declined due to lack of burning. Grasses such as *Themeda australis* are known to respond well to fire (Lunt 1990). Many remnants are surrounded by improved pastures that rarely, if ever, burn. The isolation of remnants from larger stands of forest due to clearing has possibly led to a decrease in fire frequency. This may have affected populations species adapted to regenerate after fire (e.g. legumes). Intense fire can still occur in the larger remnants. Most of Warra State Forest (now partly reserved as Warra National Park) was burnt by an intense fire in January 1994 (NSW State Forests pers. comm.). This intense fire stimulated the germination of the rare species *Muehlenbeckia costata* and *Monotaxis macrophylla*.

Vegetation management

The remnant grassy woodland communities on more fertile soils are significantly influenced by grazing pressure and management of surrounding lands. The ground cover of New England Peppermint (communities 8, 9 & 10) and Ribbon Gum/ Mountain Gum (communities 6 and 7) remnants are often dominated by exotic pasture species and tree regeneration may be suppressed due to grazing pressure. There are few sites within these communities that contain a shrub layer. One aim of management should be to induce the germination of species of wattle through fire and protection from continuous grazing. Morgan and Terrey (1990) recommended the destocking of state forests in the region.

Some disturbances to native vegetation are direct and severe. These include impoundment of lagoons, clearing of woody vegetation and ploughing of native ground cover. These processes can be controlled through regulations, incentives and education. Other disturbances are more indirect and more difficult to control. For example, riparian vegetation (community 23) is being degraded through stock trampling river banks to access water, weeds invading via creeklines and changes in water quantity and quality due to the removal of vegetation in catchments and

pollution from a range of sources. Controlling these threats requires both catchment management (controlling pollution) and local management (piping water to stock in paddocks distant from creeklines).

Although some plant communities have been severely cleared, modified and fragmented in the study area, others still contain large numbers of remnants that are linked by corridors. The role of corridors has been subject to a large debate in the literature but most commentators consider corridors have a role in maintaining species in a landscape (see review by Dawson 1994). Management should aim to maintain these remnants as they form a source for 'natural' revegetation. Conservative land management (Nadolny 1995) of low grazing pressure and less pasture improvement would assist with restoring grassy forest and woodland communities. The cost-benefits of further pasture improvement in areas with poorer soils is questionable (Nadolny 1998). Sustainable agricultural practices that use a diversity of approaches to grazing and cropping may meet some of the requirements of protecting herbaceous plant species in the Bioregion (McIntyre 1994).

Revegetation through the planting of indigenous trees, shrubs and ground cover species is appropriate in areas that have been extensively cleared, degraded or severely affected by dieback (Barrett & Ford 1993). In the study area this mainly includes plant communities containing Blakely's Red Gum, Yellow Box and New England Peppermint as well as riparian vegetation. However, revegetation is a very costly solution, so if it is to be undertaken it should be based on the best information available. It should be undertaken in places where perhaps 80% of the vegetation has been cleared. While revegetation programs may never restore the vegetation and associated biodiversity to a pre-clearing form, some studies show that tree planting can increase biodiversity, probably due to habitat complexity. For example, Chilcott et al. (1997) recorded more microarthropod species in windbreaks than in open pasture. Revegetation may also redress the problem of dieback in plant communities where the remnant patch sizes are small and vulnerable, or the species themselves are inherently susceptible (Jones et al. 1990).

Revegetation should not simply target critical habitats or species, but should be undertaken with landscape processes in mind such as establishing corridors for wildlife movement, or increasing the size of existing remnants to increase the populations and viability of the species in them.

Conservation

The conservation and management of the natural biota is dependent on knowledge of the resource and ecosystem dynamics. This study has begun to address these aims by defining and mapping 24 plant communities and quantitatively correlating them with physical explanatory variables such as geology and altitude. Nationally, State or regionally rare or threatened species are listed and discussed. Sites of botanical significance are listed and proportions remaining of plant communities are estimated. These data can be used for planning the protection of key floristic elements in the landscape, but will not address fauna or abiotic values.

The five conservation reserves totalling 1904 ha managed by the NSW National Parks and Wildlife Service, account for 0.72% of the study area. Two reserves centre on deflation lagoons on the basalt plateau near the town of Guyra-Mother of Ducks Lagoon Nature Reserve (102 ha) and Little Llangothlin Nature Reserve (254 ha). Three forest conservation reserves were established as a consequence of the 1998 Comprehensive Regional Assessment of the forests of north-eastern NSW. They mainly sample stringybark communities. The former Warra Flora Reserve and Warra State Forest were subsumed into the Warra National Park (1918 ha). Most of this National Park falls on the Glen Innes map sheet to the north, with only 440 ha within the study area. Mount Duval State Forest was dedicated as the Duval Nature Reserve (243 ha) and Boorolong State Forest was dedicated as Boorolong Nature Reserve (865 ha).

The proportion of the study area reserved (0.7%) is less than one tenth for the New England Bioregion as a whole (7.5% in Pressey et al. in press and Benson 1999). Most of the area reserved in the NET Bioregion is located on its eastern edge bordering on the rugged terrain of the eastern escarpment with other reserves concentrated on granite or acid volcanic substrates in the west and north (Fig. 34). The central part of the bioregion is more extensively cleared and contains far less reserves. This highlights the need to address reservation at finer scales than bioregions, such as at the province or landscape level of classification used in Pressey et al. (in press) or at the plant community level (Benson 1989).

Of the 24 plant communities 16 are sampled in reserves in the study area. However, only four of these have more than 5% of their estimated pre-European extent reserved in the study area (Table 4). The remainder are very poorly or poorly reserved, with less than 5% of their pre-European extent reserved (Table 4). No communities are adequately reserved as defined in this paper (> 10% of pre-European extent protected). Some communities may have a different degree of reservation over their full range but cannot be established until their range is mapped. It is known, for example that community 17 (*Eucalyptus obliqua-E. nobilis*) is well protected in reserves such as Werrikimbee, Barrington Tops and Ben Halls Gap National Parks. Alternatively, the *Eucalyptus nova-anglica* communities 8–10 are known by the authors not to be well protected in reserves outside the study area.

There is little scope for conservation through reservation in areas where most of the vegetation remains in small, isolated remnants of varying vigour, although some TSRs provide scope for protecting reasonable-sized remnants (Williams & Metcalfe 1991). Only scattered remnants of communities 1–3, 6–10, 19 and 24 remain. For these communities it will not be possible to meet the JANIS (1996) criterion that 15% of the pre-European extent of ecological communities should be protected in conservation reserves. However, if the naturally vegetated part of 'Wattleridge' and portion 14 Parish Hall were reserved, this criterion could be met or exceeded for the leucogranite plant communities 11, 12, 14, 15, 20–22. This would enlarge the present Warra National Park and would also protect a large number of rare species. Other large patches of vegetation where reserves could be established include: Avondale State Forest, parts of Days Ridge, Mount Nobbler and areas on acid volcanic substrate near Reedy Creek.

Depending on their status outside the study area, plant communities 1, 6, 7, 8, 9, 10 and 24 are under long term threat and may warrant listing as endangered ecological communities under the NSW Threatened Species Conservation Act 1996. Certainly, further clearing of them should be discouraged.

The future of the native flora in this rural landscape will largely depend on appropriate management of private land and on public lands such as state forests, roadsides and TSRs. Five key conservation programs are required:

- controls on clearing and logging;
- pursual of conservation or property agreements over remnants on private land;
- management of the understorey in forest remnants including appropriate grazing and fire regimes;
- control of problem weed species;
- revegetation of over-cleared areas such as valley bottoms on the basalt plateau.

These programs could be designed and coordinated through a regional vegetation management plan under the NSW Native Vegetation Conservation Act. This study provides baseline data for the design and implementation of vegetation planning for the Guyra 1: 100 000 map sheet area. These data are also comprehensive enough to be incorporated into modelling procedures (Ferrier & Watson 1997) for single species restoration projects.

The future of the remnant vegetation in the 'variegated' landscapes of the New England Bioregion will largely depend on the attitudes of local people to landscape

Fig. 40. Important stands of roadside vegetation are being sign-posted by local governments in the study area. This helps to alert the public and council workers about the presence of this vegetation and can help to protect it from disturbances such as road widening.

management. There are some encouraging signs as more landholders discover the benefits of maintaining native vegetation cover (summarized in Gillespie 2000). The signposting of significant vegetation on public roadsides by Dumaresq Shire Council (Fig. 40) is an example of the active and positive role that local government and local communities can take in nature conservation.

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Appendix 1. Plant species list with their occurrence in plant communities 1–24 for the Guyra 1: 100 000 map sheet.

Communities 6 & 7 are combined and community 8 was not sampled. The total of 889 taxa is composed of 664 taxa from 312 sites, 17 taxa recorded outside quadrats marked 'A', 43 taxa from NSW National Herbarium database marked 'B' (taxa not collected within the last 40 years are indicated by the year of the last collection), 119 taxa from the University of New England Herbarium (Department of Botany) database marked 'C', 3 orchid taxa from Peter Metcalfe (pers. comm.) marked 'D', 35 wetland taxa from Dorothy Bell (pers. comm.) marked 'E', 2 taxa from NSW NPWS ROTAP database marked 'F' and 6 rare species collected from the Backwater leucogranite by J.T. Hunter (pers. comm. 1996) marked 'G'. The Rare or Threatened Australian Plant list (Briggs & Leigh 1995) code is listed in parentheses: **E** *= Endangered,* **V** *= Vulnerable;* **R** *= Rare;* **K** *= Poorly Known. Species listed under the NSW Threatened Species Conservation Act are coded:* **e** *= endangered,* **v** *= vulnerable. Introduced species are marked with an asterisk.*

Botanical Name	Plant Community Number (number of sites)																					
	1	2	3	4	5	6/7	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
BRYOPHYTES																						
Sphagnaceae																						
Sphagnum cristatum																		4				
PTERIDOPHYTES																						
Adiantaceae																						
Adiantum aethiopicum		1	2	1				1	1	1			1	1	10	1					11	
Aspleniaceae																						
Asplenium australasicum [A]															+							
Asplenium flabellifolium	2	5	9	1		4				1					19	4			1		3	
Azollaceae																						
Azolla filiculoides [E]																						
Blechnaceae																						
Blechnum cartilagineum										1					3							
Blechnum minus [B,1930]																						
Blechnum nudum															1						1	
Blechnum wattsii																					2	
Doodia aspera															3							
Doodia caudata			1						1	2				1	3						1	
Cyatheaceae																						
Cyathea australis [A]															+							

Botanical Name	Plant Community Number (number of sites)																					
	1	2	3	4	5	6/7	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Davalliaceae																						
Davallia solida var. *pyxidata*										+					1				1			
Dennstaedtiaceae																						
Pteridium esculentum		10	7	3	3	17	1	8	13	12	1	2	9	5	33	18		1			8	
Dicksoniaceae																						
Calochlaena dubia										4			1		6							
Dicksonia antarctica											+				1							
Dryopteridaceae																						
Polystichum formosum						1																
Gleicheniaceae																						
Gleichenia dicarpa										1								2				
Isoetaceae																						
Isoetes muelleri [C]																						
Lindsaeaceae																						
Lindsaea microphylla										2												
Lindsaea linearis																				1		
Lycopodiaceae																						
Lycopodiella lateralis																		1				
Marsileaceae																						
Marsilea costulifera [E]																						
Marsilea hirsuta [C]																						
Marsilea mutica [C]																						
Ophioglossaceae																						
Botrychium australe								1					1			1						
Ophioglossum lusitanicum			1																			
Polypodiaceae																						
Pyrrosia rupestris						1				2			1		7	1			1			

Botanical Name	Plant Community Number (number of sites)																					
	1	2	3	4	5	6/7	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Psilotaceae																						
Psilotum nudum [c]																						
Sinopteridaceae																						
Cheilanthes distans		1	1											3								
Cheilanthes sieberi subsp. *sieberi*	12	8	18	2	8	2		2	1	2				3	2	1	1		2		3	
Pellaea nana	2	3.	8		1	2								2	2						1	
GYMNOSPERMS																						
Cupressaceae																						
Callitris oblonga subsp. *parva* **(V, v)**													1								2	
ANGIOSPERMS																						
Acanthaceae																						
Brunoniella australis		1																				
Brunoniella pumilio										1												
Alismataceae																						
Damasonium minus [c]																						
Amaranthaceae																						
Alternanthera denticulata																					3	
Alternanthera sp. A	2		1																			
Anthericaceae																						
Caesia parviflora	+	1																				
Dichopogon fimbriatus	2	3	5	3	2	6	1	2	1			1			6	1	1	1				
Dichopogon strictus	1																1					
Laxmannia compacta [c]																						
Laxmannia gracilis			1																1			
Thysanotus tuberosus subsp. *tuberosus*	1						1	1														
Tricoryne elatior	2	1	2													1						
Apiaceae																						
**Ammi majus* [c]																						

Botanical Name	Plant Community Number (number of sites)																					
	1	2	3	4	5	6/7	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Apiaceae cont.																						
**Berula erecta* [A]			+																			
Centella asiatica [E]																						
**Ciclospermum leptophyllum*																					1	
**Conium maculatum* [B]																						
Daucus glochidiatus	2	1	7			4							2	1	4							
Daucus glochidiatus form C		1																				
Daucus glochidiatus form F	1	2	1		1										1							
Eryngium ovinum [C]																						
Eryngium vesiculosum						1									7	5						
Hydrocotyle geraniifolia		1				1		2	1	1			3		18	8		1	1		2	
Hydrocotyle laxiflora	8	22	26	2	2	21	3	6	3	2			5	4	21	14	2	1			1	
Hydrocotyle peduncularis										1												
Hydrocotyle tripartita																1					9	4
Lilaeopsis polyantha																						1
Oreomyrrhis eriopoda		1	1											1	1	2						
Platysace ericoides									1	7		3	1		1				2	2		
Platysace lanceolata										1									4			
Trachymene anisocarpa								1		1			1		1				1			
Trachymene incisa subsp. *incisa*	1				2	2			2	3			3	1	2	4			2			
Araliaceae																						
Polyscias sambucifolia subsp. A		1		1					3	5		1	3		3	2			1			
Asphodeliaceae																						
Bulbine bulbosa	4	1	9		1	5	2	2	2				3	2	3							
Asteraceae																						
Ammobium alatum	2	1	2			8	1	1							1						4	
**Anthemis cotula* [C]																						
**Aster subulatus* [C]																						
**Bidens pilosa*						1																

Botanical Name	Plant Community Number (number of sites)																					
	1	2	3	4	5	6/7	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Asteraceae cont.																						
Brachyscome aculeata					1	1							1									
Brachyscome angustifolia var. *heterophylla*	4	5	4		2	1			2				1		1	2	1	1				
Brachyscome dissectifolia [C]																						
Brachyscome graminea [C]																						
Brachyscome heterodonta var. *heterodonta*	2	2																				
Brachyscome microcarpa		2	1	1	6	1			1	4	2	3	3	1	6	6					2	
Brachyscome nova-anglica		5	3	2		6		1	8	3			7		8	3			1		1	
Brachyscome procumbens	1	1	3	1											1							
Brachyscome radicans																						4
Brachyscome scapigera		1			1	1											1	1				
Brachyscome spathulata		2	5	1					1						4			1				
Brachyscome stuartii						1													2		1	
Brachyscome tenuiscapa var. *pubescens*		3			1			3	2	2				3	1	3			1			
Bracteantha bracteata		3				8		2	3	2			3		3	1	1	1			3	
Calotis cuneifolia	3	5	3	1		2											1					
Calotis dentex				1					1	1												
Calotis lappulacea [C]																						
**Carthamus lanatus* [C]																						
Cassinia compacta [C]																						
Cassinia laevis		1																				
Cassinia quinquefaria	6	7	8	2	1		1															
Cassinia uncata					2																	
Centipeda cunninghamii [E]																						
Centipeda minima [C]																						
Chrysocephalum apiculatum	6	6	1		4	4	2	3	6	5		2	7	2		2	3			1	1	
**Cirsium vulgare*	3	13	15		2	18	2	1					1		16	5	1	1			6	
**Conyza albida*	1	3	3		1	8		3	3				3	2	3	5					9	1
**Conyza bonariensis*	1														1							
**Conyza canadensis* var. *canadensis* [C]																						

Botanical Name	Plant Community Number (number of sites)																					
	1	2	3	4	5	6/7	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Asteraceae cont.																						
Cotula australis	2	1	5																			
Craspedia variabilis		1				6	2					1	1	1	4	3		2				
**Crepis capillaris*	2			1		1		1							2						3	
Cymbonotus lawsonianus	4	8	12			2	3								1							
Euchiton gymnocephalus	6	22	21	3	4	7	1	2	6	3			7	1	15	10	1				4	
Euchiton involucratus						1							1									2
Euchiton sphaericus	1	2				2																
**Gamochaeta americana*	3							1	1												1	
**Gamochaeta spicata*	1		1			1	1									1					2	
Helichrysum rutidolepis									2	1			2		1						2	
Helichrysum scorpioides		1				1		1	1						2						1	
**Hypochaeris glabra*	1	5	6	1												1						
**Hypochaeris radicata*	13	36	36	6	15	20	6	9	11	6	2	1	9	5	29	20	3	2	1		13	
Lagenifera gracilis			1																			
Lagenifera stipitata	5	6	10		2	1		1		1					8	2						
Leptorhynchos squamatus subsp. A	3	2			1	3	2	1														
**Leucanthemum vulgare*			1		1	6	1	1													3	
Leucochrysum albicans var. *albicans*						1		1								1						
**Matricaria perforata* [c]																						
Microseris lanceolata	1	1				1																
Olearia alpicola [c]																						
Olearia argophylla															6	1						
Olearia cydoniifolia [c]																						
Olearia elliptica	1	3	3																			
Olearia erubescens				1	1																	
Olearia oppositifolia												2			5	1						
Olearia ramosissima		1							1	1												
Olearia ramulosa										1										1		
Olearia rosmarinifolia																					1	

Botanical Name	Plant Community Number (number of sites)																					
	1	2	3	4	5	6/7	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Asteraceae cont.																						
Olearia viscidula	2	4	4	5	1		1								1	1						
Ozothamnus diosmifolius			2										1			1	2		1			
Ozothamnus obcordatus [C]																						
**Picris hieracioides*		1				2							1									
Podolepis hieracioides						1			1	1		1										
Podolepis jaceoides [C]																						
Podolepis neglecta [B]																						
Pseudognaphalium luteoalbum [E]																						
Rhodanthe anthemoides					2		1															
Senecio bipinnatisectus						2																
Senecio diaschides	1	3	2	1	2	5			2				1	1	2	2	1	1			1	
Senecio gunnii															1							
Senecio hispidulus var. *hispidulus*		2	2	1		1			1						3						1	
Senecio lautus subsp. *lanceolatus*													1								1	
Senecio linearifolius						1																
Senecio quadridentatus		1	2	3		1									1						1	
Senecio sp. E	1	7	8	2		4		1	2	4	1		9	3	23	12	1	1	1		2	
Sigesbeckia australiensis						1									2							
**Sigesbeckia orientalis*			1																			
**Silybum marianum* [C]																						
Solenogyne bellioides	2	4	4		1	1				1					1	2					2	
Solenogyne dominii		1					1															
Solenogyne gunnii		2	2												3	1						
**Sonchus asper* subsp. *glaucescens*	1	2	4			2		1													1	
**Sonchus oleraceus*	1		1																			
Stuartina muelleri [C]																						
**Taraxacum officinale*	4	14	16		1	12	2	1			1				9	6	1				3	
**Tripleurospermum inodorum*						1																
Triptilodiscus pygmaeus [A]	+																					

Botanical Name	Plant Community Number (number of sites)																					
	1	2	3	4	5	6/7	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Asteraceae cont.																						
Vittadinia cervicularis var. *subcervicularis*			1																			
Vittadinia cuneata	4	3	8		1		1		1					2		1						
Vittadinia dissecta var. *hirta* [C]																						
Vittadinia muelleri	3						1															
**Xanthium spinosum* [E]																						
Bignoniaceae																						
Pandorea pandorana			2																			
Boraginaceae																						
Cynoglossum australe	3	6	7	1		8		3						1	3	2					1	
**Echium plantagineum* [C]																						
Myosotis australis	1				1																	
**Myosotis caespitosa*																					1	
**Myosotis discolor*																					1	
Brassicaceae																						
**Brassica rapa* subsp. *sylvestris* [C]																						
Cardamine gunnii						1																
Cardamine paucijuga																					2	
**Lepidium africanum*			2																			
Rorippa laciniata						1																
Rorippa nasturtium-aquaticum [E]																						
**Rorippa palustris* [B]																						
**Sisymbrium officinale*			3																			
**Sisymbrium orientale*						1																
**Turritis glabra* [C]																						
Burmanniaceae																						
Burmannia disticha [C]																						
Cabombaceae																						
Brasenia schreberi [E] **(R)**																						+

Botanical Name	Plant Community Number (number of sites)																					
	1	2	3	4	5	6/7	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Campanulaceae																						
Wahlenbergia communis			2			3	2															
Wahlenbergia gracilis	2	2	1	1		3			1	4			1	1	2		1				5	
Wahlenbergia graniticola		1			2	1			2				1								2	
Wahlenbergia littoricola	1				1																	
Wahlenbergia luteola	6	9	11		4	1									2	1	1				1	
Wahlenbergia planiflora subsp. *longipila*	3	3	8		1	1	1	2	1				1		1				1			
Wahlenbergia planiflora subsp. *planiflora*	13	8	2		2		1							1	1						1	
Wahlenbergia queenslandica	2	4	4	2	3	1	2			1			1									
Wahlenbergia stricta subsp. *stricta*	3	10	14		3	14	1	4	6				6	3	21	10	2	1			4	
Caprifoliaceae																						
**Lonicera japonica*																1						
Caryophyllaceae																						
**Arenaria leptoclados*						2																
**Cerastium fontanum* subsp. *vulgare*	1	5	6		2	8	2								4	1		1			2	
**Cerastium glomeratum* [C]																						
**Dianthus armeria*	1		1		1	2															2	
**Paronychia brasiliana*	7	20	15	1	1	2	1	1							4	5					1	
**Petrorhagia nanteuilii*	6	8	7		3	10	1										1				2	
**Polycarpon tetraphyllum*		3	4			1															1	
Scleranthus biflorus	12	26	22	3	3	13	2	7	1					2	10	14	1				3	
**Silene gallica*						2											1					
**Spergularia rubra* [B]																						
Stellaria angustifolia			3		1		1									1					4	5
**Stellaria media*		1	5		1										2							
Stellaria pungens	1	4	5	2		5									5						1	
Casuarinaceae																						
Allocasuarina littoralis									3	12			5	2	5	1	1	1	3	1		
Allocasuarina rigida subsp. *rigida*									1						1				1			
Casuarina cunninghamiana [C]																						

Botanical Name	Plant Community Number (number of sites)																					
	1	2	3	4	5	6/7	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Celastraceae																						
Maytenus silvestris		1								2					3							
Centrolepidaceae																						
Centrolepis strigosa [E]																						
Chenopodiaceae																						
Atriplex semibaccata [B]																						
**Chenopodium album* [B]																						
Chenopodium carinatum		1																				
Chenopodium pumilio [C]																						
Einadia hastata	4	6	7							1					1	1						
Einadia nutans	5	4	6	1		1	1															
Clusiaceae																						
Hypericum gramineum	12	18	13	1	7	10	3	7	5	1			5	1	6	15	3				2	2
Hypericum japonicum																						1
**Hypericum perforatum*	1																					
Colchicaceae																						
Wurmbea dioica			2																			
Commelinaceae																						
Commelina cyanea [C]																						
Convolvulaceae																						
**Convolvulus arvensis*						1																
Convolvulus erubescens	1		6			1																
Dichondra repens	18	36	34	3	9	15	4	2	2	1			3	5	26	19	2	2			5	
Dichondra sp. A			1																			
Crassulaceae																						
Crassula helmsii																					1	
Crassula sieberiana	3	7	14	1	1	4	1						1	4	2	4			1		2	

Botanical Name	Plant Community Number (number of sites)																					
	1	2	3	4	5	6/7	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Cyperaceae																						
Baumea nuda [B]																						
Baumea rubiginosa																		1			1	
Bulbostylis densa																					1	
Carex breviculmis	2	2	5		1			1		1		1	4	3	8	6		1				
Carex chlorantha																					1	
Carex fascicularis [B]																						
Carex gaudichaudiana						2							1		1						10	1
Carex incomitata			1			3									2	3			1		3	
Carex inversa	8	15	12	1	3	2	4	2	1							1	1				1	
Carex polyantha [C]																						
Carex tereticaulis																					1	1
Caustis pentandra					1																	
Cyperus difformis [C]																						
**Cyperus eragrostis*																			1			
Cyperus flaccidus [E]																						
Cyperus flavidus [E]																						
Cyperus gracilis		1																				
Cyperus gunnii [C]																						
Cyperus lhotskyanus																					1	
Cyperus lucidus																					5	
Cyperus sanguinolentus																					1	1
Cyperus sphaeroideus																					1	1
Eleocharis acuta																					2	6
Eleocharis dietrichiana																						1
Eleocharis gracilis																						1
Eleocharis pusilla [C]																						
Eleocharis sphacelata																					3	2
Fimbristylis dichotoma						1																
Gahnia aspera															1			1				

Botanical Name	Plant Community Number (number of sites)																					
	1	2	3	4	5	6/7	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Cyperaceae cont.																						
Gahnia sieberiana										+			1					1	1			
Isolepis cernua [B]																						
Isolepis fluitans [E]																						
Isolepis habra [E]																						
Isolepis hookeriana [E]																						
Lepidosperma gunnii									1	2									4			
Lepidosperma laterale			4	2					2	8			1	1	9			1	1	2	1	
Lepidosperma limicola																		1				
Lipocarpha microcephala [E]																						
Ptilothrix deusta																				1		
Schoenoplectus mucronatus																					1	
Schoenoplectus validus																					1	
Schoenus apogon	2		5		2	5	3	3	3				1	2	4	1		3			2	3
Scirpus polystachyus																					6	
Dilleniaceae																						
Hibbertia acicularis			1							3									2			
Hibbertia cistoidea							1															
Hibbertia linearis	11	14	16	5	13			1	4	6					2	4		1	4	2		
Hibbertia obtusifolia [C]																						
Hibbertia riparia	2	3			2			1	6	8	1					1		1	1	2		
Hibbertia rufa																		2				
Hibbertia serpyllifolia [C]																						
Hibbertia sp. B		2			1																	
Droseraceae																						
Aldrovanda vesiculosa [E] **(e)**																						+
Drosera burmannii [E]																						
Drosera peltata			3		3		1															
Drosera spatulata																		1				

Botanical Name	Plant Community Number (number of sites)																					
	1	2	3	4	5	6/7	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Elatinaceae																						
Elatine gratioloides																					2	
Epacridaceae																						
Brachyloma daphnoides	1	4			9			3	8	9						2					1	
Brachyloma saxicola										2								1	4	2		
Epacris breviflora																		3			2	
Epacris microphylla					1					1								4		1	3	
Epacris obtusifolia																		2				
Leucopogon biflorus			1		4																	
Leucopogon ericoides					1																	
Leucopogon fraseri		2	3				3	4	1							6	2					
Leucopogon lanceolatus var. *lanceolatus*		3	2	2				1	6	9	1	3	10		23	10			3			
Leucopogon melaleucoides [B]																						
Leucopogon microphyllus																			1			
Leucopogon muticus [C]																						
Leucopogon neo-anglicus																			4			
Leucopogon virgatus					1																	
Lissanthe strigosa	18	15	19	4	4	2	1				2				1	2	3					
Melichrus procumbens									2	3									2	1		
Melichrus urceolatus	10	14	10	3	11	2	1	1	5	2	1	1	5		1	1	1	1		1	1	
Monotoca scoparia		1		2	3			1	7	11		2	8		3	4		2	3	1	1	
Eriocaulaceae																						
Eriocaulon scariosum																		1			1	
Euphorbiaceae																						
Adriana tomentosa var. *tomentosa* [C]																						
Chamaesyce drummondii						1																
Monotaxis macrophylla [G] **(e)**																						
Phyllanthus subcrenulatus [C]																						
Phyllanthus virgatus	8	6	4			1	1	1	2				2			3					3	
Poranthera microphylla	11	22	21	5	12	13	2	6	10	12		3	10	2	12	13	3		1		4	
Pseudanthus divaricatissimus [G] **(R)**																						

Botanical Name	Plant Community Number (number of sites)																					
	1	2	3	4	5	6/7	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Fabaceae																						
Acacia brownii				1																		
Acacia brunioides subsp. *brunioides* **(R)**																			1			
Acacia buxifolia subsp. *buxifolia*					4																	
Acacia dawsonii		1																				
Acacia dealbata	5	5	9		4	13		2		1					5	6					1	
Acacia falciformis		1	2		1				2	5			3	1		1			4			
Acacia filicifolia	1	2	4						10	4			9		7	2	2			1	2	
Acacia fimbriata										2					5						3	
Acacia gunnii					5				1													
Acacia implexa	7	9	5	1		1									4	1	1					
Acacia irrorata [c]																						
Acacia leucolobia									1	1										2		
Acacia melanoxylon						2									1	1					1	
Acacia neriifolia					1																	
Acacia penninervis					1																	
Acacia rubida				1	4			1		2											1	
Acacia siculiformis	1							1														
Acacia stricta [c]																						
Acacia ulicifolia					1					3			1						1			
Acacia venulosa					3																	
Acacia viscidula [c]																						
Aotus subglauca									5	1									1	1		
Aotus subglauca var. *subglauca*					1			1		1			1					1				
Bossiaea neo-anglica									1	5			1							1		
Bossiaea prostrata				1																		
Bossiaea rhombifolia subsp. *rhombifolia*																			2			
Bossiaea scortechinii	1	2			4			1	10	9		2	3			2			1	1		
Crotalaria mitchellii subsp. *laevis*								1	1													
Cullen tenax		1				4																

Botanical Name	Plant Community Number (number of sites)																					
	1	2	3	4	5	6/7	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Fabaceae cont.																						
**Cytisus scoparius* [C]																						
Daviesia acicularis [C]																						
Daviesia elliptica [A] **(R)**									+													
Daviesia genistifolia	1	1				1																
Daviesia latifolia	1	3	1		5																	
Daviesia ulicifolia [A]		+																				
Desmodium brachypodum	4	6	2	2		1			1					2	2	3	1					
Desmodium varians	18	19	29	3	6	10	4	6	5	5		1	7	3	24	17	2				1	
Dillwynia juniperina [B]																						
Dillwynia phylicoides						1			6	4			1		1	1		2	4	1	1	
Dillwynia sieberi		2	1		1	3										2					1	
**Genista monspessulana*						1																
Glycine sp. nov.																					1	
Glycine microphylla [B]																						
Glycine clandestina	10	32	33	5	6	20	1	8	8	8	1	1	9	5	33	17	1	1	1		3	
Glycine tabacina	1	2	1			2			1							1						
Gompholobium huegelii					1	2			1	1												
Hardenbergia violacea	5	9	9	4	12	3		1	8	12	2	3	5	2	8	5	2		1			
Hovea beckeri										3									4	1		
Hovea lanceolata																			1			
Hovea linearis	2	2	2		7	5		1	9	2		1	5		1	4					1	
Hovea sp. A									2	4		2	1							1		
Indigofera adesmiifolia	1	1	3										2		1							
Indigofera australis	1	4	6	3	4	1			1		1				6	1	2					
Jacksonia scoparia	5	2	1						4	2			1	1							1	
Lespedeza juncea subsp. *sericea*	3	4	1			6	2	2	1					1		1					4	
Lotus australis	1	1	1			2																
**Lotus corniculatus*																					1	
Mirbelia confertiflora									2	4									4	2	1	
Pultenaea altissima										1			1									

Botanical Name	Plant Community Number (number of sites)																					
	1	2	3	4	5	6/7	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Fabaceae cont.																						
Pultenaea campbellii **(V, v)**	1	3			5																	
Pultenaea microphylla	6	7	2			9	2	2	1	1						4		2				
Pultenaea myrtoides																		1				
Sphaerolobium minus																		1				
Swainsona galegifolia [C]																						
Swainsona monticola [A]		+																				
Swainsona oroboides [C]																						
Swainsona parviflora		+			1		1															
Swainsona sericea			1					1														
**Trifolium arvense*	3	6	1		2	4	1	1													2	
**Trifolium campestre*	4	3	7		2	6	2	1									1					
**Trifolium glomeratum*	6	3	9		1	6	1							1	1		1				2	
**Trifolium pratense*						2															1	
**Trifolium repens*	7	18	13	1	6	18	2	5						2	15	16	2	1			8	2
**Trifolium striatum* [E]																						
**Vicia sativa* subsp. *angustifolia*					+	2																
**Vicia sativa* subsp. *sativa*																					1	
Zornia dyctiocarpa var. *dyctiocarpa*	1															1						
Gentianaceae																						
**Centaurium erythraea*	5	5	5	2	3	5	1	4	1	1			2		6	4					8	
Centaurium spicatum [C]																						
**Centaurium tenuiflorum*	1						1															
Geraniaceae																						
**Erodium moschatum* [C]																						
Geranium homeanum		1																				
Geranium potentilloides								+										2				
Geranium retrorsum [E]																						
Geranium solanderi var. *grande*																1						
Geranium solanderi var. *solanderi*	18	36	36	3	6	23	2	5	2				9	4	31	17	3	1			7	

Botanical Name	Plant Community Number (number of sites)																					
	1	2	3	4	5	6/7	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Goodeniaceae																						
Dampiera stricta [C]																						
Goodenia bellidifolia subsp. *argentea*		+							1													
Goodenia bellidifolia subsp. *bellidifolia*	1				7				1	1								1			1	
Goodenia gracilis	1			+																		
Goodenia hederacea subsp. *hederacea*	5	7	4		8	3		3	13	16	2	2	7	1	3	7	3	1	3	2	1	
Goodenia macbarronii [B, 1917] **(V, v)**																						
Goodenia pinnatifida	1																					
Scaevola hookeri																		1			1	
Velleia paradoxa [B]																						
Haemodoraceae																						
Haemodorum planifolium									2	1												
Haloragaceae																						
Gonocarpus micranthus							1											3			2	
Gonocarpus micranthus subsp. *ramosissimus*																		1				
Gonocarpus tetragynus	2	9	4		9	3	2	6	12	13	1	1	8	2	6	9		1	1	1		
Gonocarpus teucrioides	1	1	1	1	1			1	2	1			1		2	3			2		1	
Haloragis heterophylla	8	4	8		2	3	3	1	1							8	2				4	
**Myriophyllum aquaticum*																					1	
Myriophyllum crispatum																					1	
Myriophyllum lophatum [C]																						
Myriophyllum simulans [B]																						
Myriophyllum variifolium																					8	6
Myriophyllum verrucosum [C]																						
Hydrocharitaceae																						
Vallisneria gigantea																					3	
Hypoxidaceae																						
Hypoxis hygrometrica var. *splendida*							1	1								+					1	

Botanical Name	Plant Community Number (number of sites)																					
	1	2	3	4	5	6/7	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Iridaceae																						
Patersonia fragilis [C]																						
Patersonia glabrata									2	7		2			1			1	3	2		
Patersonia sericea								1	3	9			1					1				
**Sisyrinchium iridifolium* [E]																						
**Sisyrinchium* sp. A [E]																						
Juncaceae																						
**Juncus articulatus*																					1	3
Juncus australis						1															3	
**Juncus bufonius* [B]																						
Juncus continuus															1						1	
Juncus falcatus [B]																						
Juncus filicaulis	3	1	4		1	1	4	1													1	2
Juncus flavidus																					1	
Juncus fockei																					1	4
Juncus holoschoenus [C]																						
Juncus homalocaulis	3							1														
Juncus laeviusculus subsp. *laeviusculus* [A]																						
Juncus ochrocoleus [B]																			+			
Juncus planifolius	1																					
Juncus prismatocarpus																					3	
Juncus sandwithii [B]																						
Juncus subsecundus	3	1	4		2		2														1	
Juncus usitatus						1	1														6	
Juncus vaginatus																						1
Luzula densiflora	3	9	13		3	8	3	3	1				2	1	9	11		1	1		1	
Luzula flaccida															1							
Juncaginaceae																						
Triglochin procera																					2	

Botanical Name	Plant Community Number (number of sites)																					
	1	2	3	4	5	6/7	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Lamiaceae																						
Ajuga australis	5	8	6	1	2	10	1		1	1			3	1	5	7					2	
Lycopus australis [C]																						
**Marrubium vulgare*	1	1	3			1									1						1	
Mentha satureioides	6	9	14	1		3	1	1					1		1	4	1					
**Mentha x piperita*																					2	
Plectranthus parviflorus	2		1											3	1				1			
Prostanthera nivea [B]																						
Prostanthera scutellarioides																			2			
**Prunella vulgaris*						1															6	
Scutellaria humilis		1	3																			
Lauraceae																						
Cassytha glabella					2																	
Cassytha pubescens					1																	
Lemnaceae																						
Lemna trisulca [C]																						
Spirodela punctata [E]																						1
Lentibulariaceae																						
Utricularia australis																						1
Utricularia dichotoma																		1			1	3
Linaceae																						
Linum marginale [B]																						
Lobeliaceae																						
Isotoma axillaris													+						1			
Isotoma fluviatilis																					1	1
Lobelia gibbosa									1													
Pratia purpurascens													1		2	1						
Pratia surrepens																					2	4

Botanical Name	Plant Community Number (number of sites)																					
	1	2	3	4	5	6/7	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Loganiaceae																						
Logania albiflora															2	1					1	
Lomandraceae																						
Lomandra elongata [C]																						
Lomandra filiformis subsp. *coriacea*	4	3	5	5	7				5	1			1			2						
Lomandra filiformis subsp. *filiformis*			2		1	1			3	3			5		1				1	1		
Lomandra glauca					1																	
Lomandra longifolia	2	6	6	2		4		5	8	12	1	3	8	5	30	12	1	1	4	1	12	
Lomandra multiflora subsp. *multiflora*	6	4	5	2	4	3	2	3	3	4	2	2	6	3	4	2			1		1	
Loranthaceae																						
Amyema miquelii	3					2				2					1	1						
Amyema pendulum subsp. *pendulum*	6	1	2	1	1	2			1										1			
Muellerina eucalyptoides [C]																						
Luzuriagaceae																						
Eustrephus latifolius			1			1				1		1	2	2	7							
Geitonoplesium cymosum			1										1									
Lythraceae																						
Lythrum hyssopifolia [E]																						
Lythrum salicaria [A]																+						
Malaceae																						
**Cotoneaster franchetii*								2							1							
**Crataegus monogyna*			2			1																
**Malus domestica*		1						1														
Malvaceae																						
**Modiola caroliniana*			1				1														1	
**Pavonia hastata* [C]																						
Menyanthaceae																						
Nymphoides geminata																						3
Nymphoides montana [C]																						

Botanical Name	Plant Community Number (number of sites)																					
	1	2	3	4	5	6/7	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Myrsinaceae																						
Rapanea variabilis															1							
Myrtaceae																						
Angophora floribunda		3	5			1																
Baeckea gunniana									1									5		1	1	
Baeckea omissa													1								1	
Callistemon pallidus													2									
Callistemon pityoides																		3				
Calytrix tetragona																			1			
Eucalyptus acaciiformis		1							1	1						9	2	2	2		3	
Eucalyptus amplifolia subsp. *sessiliflora*										1												
Eucalyptus andrewsii					6														1			
Eucalyptus banksii				6	2	1																
Eucalyptus blakelyi	19	6	4		2		1	1						2								
Eucalyptus bridgesiana	3	6	8	2	1																	
Eucalyptus caliginosa	8	40	4		8	1			12	7			8	5	5	8	3		2	1	4	
Eucalyptus cameronii										3					2	2			1			
Eucalyptus campanulata										15					1							
Eucalyptus camphora subsp. *relicta* [B] **(V, e)**																						
Eucalyptus codonocarpa **(R)**																			3			
Eucalyptus dalrympleana subsp. *heptantha*		6	7	1	9	8	3	3	10			1	1		1	7	1				4	
Eucalyptus laevopinea	9		38	8	9						2			1	5	2						
Eucalyptus melliodora	18	14	13																			
Eucalyptus michaeliana [C] **(R)**																						
Eucalyptus moluccana	1	1																				
Eucalyptus nicholii **(V, v)**					3																	
Eucalyptus nobilis		2	1			2			1	3	2	2	7	3	24	3			1		1	
Eucalyptus nova-anglica	1	2			1	5	6	8					2		1	3		1			7	
Eucalyptus obliqua						1				1			2		26			1				

Botanical Name	Plant Community Number (number of sites)																					
	1	2	3	4	5	6/7	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Myrtaceae cont.																						
Eucalyptus pauciflora			1			14		6	2				1		1	7		1			6	
Eucalyptus prava					3																	
Eucalyptus radiata subsp. *sejuncta*		1	1		2	1			4	6	2	3	6		13	15	3			2		
Eucalyptus subtilior					2																	
Eucalyptus stellulata						9		5														
Eucalyptus viminalis		6	3	1		11																
Eucalyptus youmanii **(R)**	4				8																	
Kunzea obovata									1										4	1		
Kunzea parvifolia	1				1		+															
Leptospermum arachnoides [C]																						
Leptospermum brevipes	2				4			1	1	1									2	2	3	
Leptospermum gregarium	1				1			1								1		5			1	
Leptospermum minutifolium [C]																						
Leptospermum novae-angliae									1									2	6	2	1	
Leptospermum polygalifolium subsp. *transmontanum*			1		1			2	1	1			2		1	1					15	
Najadaceae																						
Najas tenuifolia [E]																						
Nyctaginaceae																						
Boerhavia dominii [C]																						
Oleaceae																						
**Ligustrum sinense*																1						
**Ligustrum vulgare*		1																				
Notelaea linearis									2	6					2				1	1	3	
Notelaea microcarpa					1																	
Notelaea sp. A [A]												+										
Onagraceae																						
Epilobium billardiereanum subsp. cinereum		4	3	1	1	8	1	4	1					1	1						10	3
Epilobium billardiereanum subsp. hydrophilum								1													1	
Epilobium gunnianum [E]																						

Botanical Name	Plant Community Number (number of sites)																					
	1	2	3	4	5	6/7	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Onagraceae cont.																						
Epilobium hirtigerum [E]																						
**Oenothera glazioviana* [C]																						
Orchidaceae																						
Acianthus exsertus													3		2							
Acianthus sp. aff. *exsertus* [D]																						
Bulbophyllum elisae									1						2				1			
Caladenia cucullata										1												
Caladenia fuscata												2	1		1	1						
Caleana minor					1																	
Calochilus campestris [C]																						
Calochilus gracillimus [B]																						
Calochilus robertsonii					1																	
Chiloglottis trapeziformis [C]																						
Corybas fimbriatus [C]																						
Dendrobium fairfaxii														1	3				1			
Dendrobium pugioniforme																			1			
Dipodium atropurpureum [B]																						
Dipodium punctatum [A]		?+																				
Dipodium variegatum			1																			
Diuris abbreviata						7						1				2						
Diuris dendrobioides						1																
Diuris pedunculata [C] **(E, e)**																						
Diuris punctata [B]																						
Diuris sulphurea [C]																						
Eriochilus cucullatus [C]																						
Gastrodia sesamoides [C]																						
Genoplesium nudum [C]																						
Glossodia major [C]																						
Microtis unifolia						1		1								1					1	

Botanical Name	Plant Community Number (number of sites)																					
	1	2	3	4	5	6/7	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Orchidaceae cont.																						
Orthoceras strictum																1						
Prasophyllum brevilabre [C]																						
Prasophyllum odoratum [C]																						
Pterostylis abrupta [C]																						
Pterostylis alata [C]																						
Pterostylis cycnocephala [B]																						
Pterostylis fischii [C]																						
Pterostylis longifolia													1			1						
Pterostylis mutica			1												+							
Pterostylis obtusa [C]																						
Pterostylis parviflora [C]																						
Pterostylis praetermissa									1													
Pterostylis rufa			1																			
Pterostylis sp. aff. *obtusa* [D]																						
Pterostylis sp. aff. *abrupta* [D]																						
Pterostylis truncata [C]																						
Spiranthes sinensis subsp. *australis*								1														
Thelymitra ixioides var. *ixioides*																		1				
Oxalidaceae																						
Oxalis exilis	6	11	13			4	2						1			1	1				2	
Oxalis perennans	5	2	4			2	1														1	
Oxalis radicosa	1	7	5	3	12		1	2	7	1			5		2	7	1				1	
**Oxalis thompsoniae*		1	3												1							
Papaveraceae																						
**Argemone ochroleuca* subsp. *ochroleuca* [B]																						
Phormiaceae																						
Dianella caerulea		2											1		2		1				2	
Dianella longifolia						1									1							
Dianella revoluta var vinosa	1		2						11	3			3		2	1						

Botanical Name	Plant Community Number (number of sites)																					
	1	2	3	4	5	6/7	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Phormiaceae cont.																						
Dianella tasmanica										3									2			
Stypandra glauca										2												
Thelionema grande [G] **(R)**																						
Phytolaccaceae																						
**Phytolacca octandra*										1					+							
Pittosporaceae																						
Billardiera scandens var. *scandens*		2	2	1	1	1		1	6	9		2	6	1	13	5			1		1	
Bursaria longisepala [C]																						
Bursaria spinosa	11	8	20	2		1		6	4	2			4	1	11						5	
Rhytidosporum procumbens		1			4				2	1										2	1	
Plantaginaceae																						
Plantago debilis						1																
Plantago gaudichaudii	7	6	3	1	1	4	2	1	1				2	2		1					1	
Plantago hispida	1	9	13	1	1	1	1		1	1			1	1	2						1	
**Plantago lanceolata*	8	9	2			6	3	1	1								2				4	
**Plantago scabra* [C]																						
Plantago varia [C]																						
Poaceae																						
Agrostis aemula							1															
**Agrostis capillaris*						1																
Agrostis avenacea var. *avenacea*		1				5	1														7	5
**Aira cupaniana*															1							
**Aira elegantissima*	5	4	12		7	3	4	3								1						
**Aira provincialis*		3				+																
Amphibromus nervosus																						1
Amphibromus pithogastrus [E]																						
Amphibromus sinuatus [C]																						
**Anthoxanthum odoratum*	3	6	8		2	7	3	2							9	8		1			2	1

Botanical Name	Plant Community Number (number of sites)																					
	1	2	3	4	5	6/7	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Poaceae cont.																						
Aristida acuta																1						
Aristida calycina	3	1						3	3	3				3					1		2	
Aristida jerichoensis var. *subspinulifera*	5	3	4		4		1		1	2							1					
Aristida ramosa		4	6	2																	1	
Aristida ramosa var. *ramosa*	1	1	1																			
Aristida vagans		3	1		2	1										1	1					
Austrodanthonia bipartita [B]																						
Austrodanthonia caespitosa	1	1	1						2	2												
Austrodanthonia carphoides [B, 1931]																						
Austrodanthonia eriantha [B, 1947]																						
Austrodanthonia induta					1	1																
Austrodanthonia laevis	6	6	1	2	3	2							1			1	1				2	
Austrodanthonia monticola	1																					
Austrodanthonia penicillata		1				1																
Austrodanthonia pilosa var. *pilosa*	1		2	3				1	1				1		1	4					1	
Austrodanthonia racemosa var. *obtusata*	1	5	2	1												1						
Austrodanthonia racemosa var. *racemosa*	7	3	9		2	3	1	3	2				2		3	3					2	
Austrodanthonia richardsonii			1																			
Austrodanthonia tenuior		1	1		1				4	1			1					1			3	
Austrofestuca eriopoda [B]																						
Austrostipa densiflora					1																	
Austrostipa nodosa			2																			
Austrostipa pubescens										2											1	
Austrostipa rudis		1								1						1						
Austrostipa rudis subsp. *nervosa*	2	13	4	1	1	2		4	1		1		1	2	3	4					3	
Austrostipa rudis subsp. *rudis*	1		3		1																	
Austrostipa scabra subsp. *falcata*	3	4	2																			
Austrostipa scabra subsp. scabra			1																			
Austrostipa setacea [B, 1934]																						

Botanical Name	Plant Community Number (number of sites)																					
	1	2	3	4	5	6/7	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Poaceae cont.																						
Austrostipa verticillata			1																			
Bothriochloa biloba [F, 1955] **(V, v)**																						
Bothriochloa decipiens [C]																						
Bothriochloa macra	12	11	9	4	2	1	1	1						2		2					1	
**Briza minor*	3		3		3		3														1	
**Bromus alopecuros* [C]																						
**Bromus brevis*			3			2	1								1	1						
**Bromus cartharticus*																					1	
**Bromus diandrus*			1			1																
**Bromus hordeaceus*	1	1	8		1	5	1	1							1	2					3	
Bromus molliformis	1				1	2									2							
Capillipedium parviflorum									1													
**Cenchrus incertus* [C]																						
Chloris truncata						1																
**Chloris ventricosa*			1																			
Cymbopogon refractus	3	7	8	2	2	1	1	1	3	2				5		1					1	
Cynodon dactylon		2				1								1	2	3					1	
Cynodon incompletus [B]																						
**Cynosurus cristatus*	2																					
**Cynosurus echinatus*	1					1																
**Dactylis glomerata*	1	2	2			1	1								1							
Deyeuxia acuminata										2												
Deyeuxia brachyathera										1											1	
Deyeuxia gunniana									5	1								1			1	
Deyeuxia imbricata																		1			1	
Deyeuxia parviseta					1					1												
Deyeuxia parviseta var. *parviseta*					1			1	6	6		1	4		2	2		1		1	2	
Deyeuxia quadriseta													1									
Dichanthium sericeum	1																					

Botanical Name	Plant Community Number (number of sites)																					
	1	2	3	4	5	6/7	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Poaceae cont.																						
Dichelachne crinita	1	1	2			2		1								2					3	
Dichelachne inaequiglumis			1		1	1		2					2			2					1	
Dichelachne micrantha	11	20	12	5	9	4	1	4	12	10		2	6	5	9	4		1	1		2	
Dichelachne parva																		1				
Dichelachne rara		2	1		1	1		1								1					1	
Digitaria breviglumis									1						1							
Digitaria diffusa									1													
Digitaria ramularis										1											1	
**Echinochloa crus-galli* [C]																						
**Echinochloa esculenta* [C]																						
Echinopogon caespitosus var. *caespitosus*	4	2	2	1	6	1		1		1			1	1	3	3			1		1	
Echinopogon intermedius		2	3		2	3		3	2	2			1		5							
Echinopogon mckiei	2	3	2			2	1	3	2				1		1	2					2	
Echinopogon nutans var. *nutans*	1	4	3				1	3					2		2	2						
Echinopogon ovatus		2	11		1	2		1	1				1	1	2	1		2			2	
**Ehrharta calycina* [C]																						
**Ehrharta erecta* [C]																						
**Eleusine tristachya*			1																			
Elymus scaber	9	14	24	3	7	7	2	1	2	1			1		5	3					4	
Entolasia stricta			1		1	1			3	12		1	3		3	3	1		6	2	5	
Eragrostis benthamii			1					1	1												5	1
Eragrostis brownii [C]																						
**Eragrostis cilianensis* [C]																						
**Eragrostis curvula* [C]																						
Eragrostis leptostachya	6	4	1											1								
Eragrostis molybdea [C]																						
Eragrostis parviflora [C]																						
Eragrostis trachycarpa [E]																						
Festuca asperula [B]																						
**Festuca elatior*	4	1	1		1	6		1							2	2	1				4	

Botanical Name	Plant Community Number (number of sites)																					
	1	2	3	4	5	6/7	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Poaceae cont.																						
**Festuca pratensis*		1				2	1								1		1				1	
Glyceria australis																						3
Glyceria latispicea [C]																						
Hemarthria uncinata var. *uncinata*						1															1	2
**Holcus lanatus*					1	5	1	4								2		1			7	4
**Hordeum hystrix*		1																				
**Hordeum leporinum*		1	2																			
**Hordeum marinum*			1			1																
Imperata cylindrica var. *major*	2	3	4		2	3		5	11	9			8	5	15	8			1		6	
Isachne globosa													1								5	
Joycea pallida				1	1	1				3												
**Lolium perenne*	2	2	2		1	2	1	1							1						1	
Microlaena stipoides var. *stipoides*	2	10	13	2	5	3	1	2	2	3			1		9	5	1				3	
**Nassella trichotoma* [B]																						
Panicum effusum									1													
**Panicum gilvum* [E]																						
Panicum obseptum [E]																						
**Paspalum dilatatum*						1	1									1					5	
**Paspalum distichum*																					1	
Pennisetum alopecuroides	1					3															4	1
**Pennisetum villosum* [C]																						
**Phalaris aquatica*		3	2			2																
**Phleum pratense* [B]																						
Phragmites australis																					2	
**Poa annua* [C]																						
Poa clivicola								1														
Poa costiniana					1	3		1														
Poa labillardierei			3		4	7	2	2	2						1	2	1				8	
**Poa pratensis*																1					1	
Poa sieberiana	18	38	34	5	7	13	3	6	5	12	2	3	10	4	32	20	2	1	3		7	

Botanical Name	Plant Community Number (number of sites)																					
	1	2	3	4	5	6/7	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Poaceae cont.																						
Sacciolepis indica [C]																						
Sorghum leiocladum	4	3		1	1	5	1	1	2	1						5					3	
Sporobolus creber	2	5	3				1	2	2												1	
Themeda australis	13	10	9	2	7	15	4	8	12	8		1	6	2	6	11	3	1			6	
**Vulpia bromoides*		2	1		3	7		1								1					2	
**Vulpia myuros*	5	7	17		1	5	2	1							2	6	1	1			1	
Polygalaceae																						
Comesperma ericinum [C]																						
Comesperma retusum																		2				
Comesperma volubile [C]																						
Polygala japonica		1				3							1	1		1						
Polygonaceae																						
**Acetosella vulgaris*		7	2		1	9		5	1						5	3					3	
**Fallopia convolvulus* [C]																						
Muehlenbeckia costata (ms) [G] **(K)**																						
Persicaria decipiens																					6	
Persicaria hydropiper																					1	
Persicaria lapathifolia [C]																						
**Persicaria maculosa* [E]																						
Persicaria prostrata																					1	
**Polygonum arenastrum*			1																			
Rumex brownii	9	24	25			6	3	2						2	5	6					6	
**Rumex conglomeratus*																						1
**Rumex crispus*																						1
Portulacaceae																						
Neopaxia australasica [B]																						
Potamogetonaceae																						
Potamogeton crispus [C]																						
Potamogeton ochreatus																					4	1

Botanical Name	Plant Community Number (number of sites)																					
	1	2	3	4	5	6/7	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Potamogetonaceae cont.																						
Potamogeton perfoliatus																					1	
Potamogeton tricarinatus																						4
Primulaceae																						
**Anagallis arvensis*	2		1														1					
Proteaceae																						
Banksia cunninghamii subsp. A									1	3					1			4		2		
Banksia integrifolia subsp. A									9	10		3	9	1	19	12		2	1		3	
Banksia marginata [B]																						
Grevillea juniperina								3													2	
Grevillea ramosissima [B]																						
Grevillea scortechinii subsp. *sarmentosa* **(V, v)**									2	4									2	2	1	
Hakea dactyloides									1										1	1		
Hakea eriantha										7		1	1		6							
Hakea microcarpa																		4			6	
Lomatia fraseri						3		3	1		1				2	2		4			3	
Lomatia silaifolia		1		1	5			1	6	17		3	5	2	11	1		2	2	1		
Persoonia cornifolia					3			2	11	11		2	8		4	3			1	2	2	
Persoonia oleoides													1									
Persoonia procumbens **(R)**									6	2			2							1		
Petrophile canescens									3	5								1		2		
Ranunculaceae																						
Clematis aristata		1	2										1		8	1					1	
Clematis glycinoides var. *glycinoides*	1	3	10	2		3							1	1	5	3						
Ranunculus inundatus																						3
Ranunculus lappaceus	3	6	7	2	1	13	2		2				3		11	4	2					
Ranunculus sp. A																					1	
Restionaceae																						
Baloskion fimbriatum [B]																						
Baloskion stenocoleum																		5		1	4	

Botanical Name	Plant Community Number (number of sites)																					
	1	2	3	4	5	6/7	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Restionaceae cont.																						
Empodisma minus																		1				
Lepyrodia anarthria																		4			1	
Rhamnaceae																						
Cryptandra amara var. *amara*			1																		1	
Cryptandra amara var. *longiflora*	1					1		1													1	
Cryptandra lanosiflora [G] **(R)**																						
Cryptandra propinqua [C]																						
Cryptandra scortechinii						1													1	2		
Discaria pubescens [C] **(R)**																						
Pomaderris andromedifolia [A]		+																			+	
Pomaderris eriocephala [A]	+																					
Pomaderris lanigera															1							
Pomaderris nitidula																					2	
Rosaceae																						
Acaena agnipila [B]																						
Acaena novae-zelandiae	3	20	27	1	2	13	1	8	2				5	3	24	17	2	1			5	
Acaena ovina	2	13	10	1	1	10	4	1								1	1				3	
**Potentilla recta* [B]																						
**Pyracantha angustifolia*																						
**Rosa rubiginosa*	6	14	10		2	7	3	2								5						
Rubus parvifolius	5	9	11	1	2	19	3	9	8	3			9	5	32	18	1				8	
**Rubus ulmifolius*		9	6		2	11	2	1							6	12		1			9	
**Sanguisorba minor* subsp. *muricata*																					1	
Rubiaceae																						
Asperula charophyton [A] **(R)**																						+
Asperula conferta	12	10	14		2	16	5	3	1					1	1	4	1				6	
Asperula gunnii																		2				
Coprosma hirtella [A]															+							
Galium binifolium			1		1																	

Botanical Name	Plant Community Number (number of sites)																					
	1	2	3	4	5	6/7	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Rubiaceae cont.																						
Galium ciliare	4	10	11	2		14		2	2	1			7	1	21	11					4	
Galium gaudichaudii		2	12	3	1	1				1			2		2	4						
Galium liratum															1						1	
Galium migrans	2	3	5												1	1						
Galium propinquum		7	9	3	2	1					1	1	3	1	2	1	1				1	
Leptostigma reptans [E]																						
Opercularia aspera	9	5	5	5	3		2		1		1		4		1	3	1					
Opercularia hispida	1	3	5	1	2			1	9	9			4	4	7	6	1				1	
Pomax umbellata									2	12			2		1							
Rutaceae																						
Boronia algida [C]																						
Boronia anemonifolia var. *anemonifolia*																			2			
Boronia anethifolia [C]																						
Boronia microphylla					1																	
Boronia polygalifolia	1		1																			
Correa reflexa var. *reflexa*	1				2					4		1			2				1			
Leionema ambiens [G] **(R)**																						
Phebalium squamulosum [C]																						
Zieria cytisoides										1												
Zieria fraseri subsp. B										1									1			
Zieria laevigata [C]																						
Zieria smithii subsp. A																			1			
Salicaceae																						
**Salix babylonica*																					1	
Santalaceae																						
Choretrum pauciflorum									6									1		2		
Exocarpos cupressiformis	1	1		2		5			1	2					2	1	1					
Exocarpos strictus		1				2																
Santalum obtusifolium															1							
Thesium australe **(V, v)**						4										1						

Botanical Name	Plant Community Number (number of sites)																					
	1	2	3	4	5	6/7	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Sapindaceae																						
Dodonaea boroniifolia [C]																						
Dodonaea viscosa subsp. *angustifolia*		1								1									1			
Dodonaea viscosa subsp. *angustissima* [C]																						
Dodonaea viscosa subsp. *spatulata*					1				1	3					1				1		1	
Scrophulariaceae																						
Derwentia arcuata						1		1	1	3			1		1	1						
Derwentia derwentiana subsp. *derwentiana*															2						1	
Euphrasia orthocheila [F] **(R)**																						
Glossostigma diandrum [E]																						
Gratiola nana [B]																						
Gratiola peruviana									1												5	
Limosella australis [B]																						
**Linaria pelisseriana* [E]																						
Mimulus gracilis [E]																						
**Verbascum thapsus* subsp. *thapsus*	3	7	8	1	2	6				1											3	
**Verbascum virgatum* [B]																						
**Veronica arvensis*																					1	
Veronica calycina	7	22	27	3	11	7	1	4	5	3			7	1	18	15		1			2	
Veronica gracilis [B]																						
Veronica notabilis [C]																						
**Veronica peregrina*					1																	
Veronica plebeia	8	11	5	1	1	3	1						1	3	3	2	2	1	1			
**Veronica serpyllifolia* [A]																+						
Veronica sp. C																					1	
Smilacaceae																						
Smilax australis						4			1	1		2	1		22	5		1			1	
Solanaceae																						
**Datura stramonium* [C]																						
Solanum aviculare					1																	

Botanical Name	Plant Community Number (number of sites)																					
	1	2	3	4	5	6/7	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Solanaceae cont.																						
Solanum brownii						2							1		1							
**Solanum nigrum*		2				1		1							1			1				
Solanum opacum		2	1			3									2							
Solanum prinophyllum		1				1				1					2	2					1	
Stackhousiaceae																						
Stackhousia monogyna	3	5	2				1									1						
Stackhousia viminea	2	1	2		2	1				3			2			1			2			
Stylidiaceae																						
Stylidium graminifolium					5	1	1	5	12	7		1	4		1	2		2	2	1	1	
Thymelaeaceae																						
Pimelea curviflora var. *divergens*	8	7	11			3	1									1						
Pimelea glauca						1	1			1												
Pimelea ligustrina																					2	
Pimelea linifolia										1												
Pimelea linifolia subsp. *linifolia*	1	1	1		3	8		3	3	4								1	2	1	3	
Typhaceae																						
Typha domingensis [c]																						
Typha orientalis																					2	
Urticaceae																						
Urtica incisa	2	11	15		1	3									1						3	
Verbenaceae																						
**Verbena bonariensis*																					3	
Violaceae																						
Hybanthus monopetalus		8	4	1	9	6	1	1	1				1		2	5			1			
Hymenanthera dentata						4							1		1	1					2	
Viola betonicifolia	7	14	11	2	2	16	2	1	5	1			8	2	10	8	2		1		2	
Viola caleyana																					5	

Botanical Name	Plant Community Number (number of sites)																					
	1	2	3	4	5	6/7	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Violaceae cont.																						
Viola hederacea	1		1		2	1				1			5		13	3		1			4	
Viola hederacea form d				1											1							
Winteraceae																						
Tasmannia stipitata [A]															+							
Xanthorrhoeaceae																						
Xanthorrhoea glauca subsp. *glauca*		1	2		3													2				
Xyridaceae																						
Xyris gracilis subsp. *gracilis*													+					1				
Xyris operculata																		1				

The biogeographical attributes of the threatened flora of New South Wales

Karel Mokany and Paul Adam

Mokany, K. and Adam, P. (School of Biological Science, University of New South Wales, NSW, Australia 2052) 2000. The biogeographical attributes of the threatened flora of New South Wales Cunninghamia *6(4): 873–892.*

The geographic distribution, community distribution, taxonomy, and growth form of the flora listed as threatened under Schedules 1 and 2 of the New South Wales *Threatened Species Conservation Act 1995* were examined. The North Coast and Central Coast Botanical Divisions have the highest number of threatened plant species, with both these divisions having significantly more threatened plant species than expected. A large disparity between the east and the west of the state was found, with the eastern divisions generally containing larger numbers and higher proportions of threatened plant species than the western divisions. Rainforest, sclerophyll forest and sclerophyll woodland communities were all found to contain large numbers of threatened plant species, with woodland containing more threatened plant species than expected. Some large families and genera contain significantly more threatened plant species than expected (e.g. Myrtaceae, Proteaceae, *Grevillea* and *Zieria*), while others contain significantly fewer (e.g. Asteraceae, Poaceae and Cyperaceae). The analysis of habit showed that fewer than expected threatened plant species were herbs. Possible explanations for the apparent distribution of threatened flora are discussed.

Introduction

The identification and protection of species facing a high risk of extinction in the near future is one of the central objectives of modern conservation (Keith 1998). In New South Wales, the *Threatened Species Conservation Act 1995* provides for the identification of threatened species, endangered ecological communities and endangered populations, as well as the implementation of mechanisms to restrict further extinction of species and to reverse the processes which have caused threat.

The listing of a species as threatened under the *Threatened Species Conservation Act 1995* serves to trigger a range of mechanisms aimed at protecting that species, including preparation of recovery plans, requirements for species impact statements and preparation of threat abatement plans (Smith 1997). The development of threatened species lists in itself is also useful, as they can function as a resource document for conservation, as important tools for legislative purposes, as sources of information in increasing public awareness of conservation issues and as a focus for research planning (McIntyre 1992). In NSW, species, populations, ecological communities and key threatening processes are listed on purely scientific grounds by the independent NSW Scientific Committee. This represents a significant strength of the *Threatened Species Conservation Act 1995* (Adam et al. 1997).

The criteria for listing on the Schedules of the *Threatened Species Conservation Act 1995* are defined in the legislation (for Endangered species s.10, for species presumed extinct s.13, and for Vulnerable species s.14). The criteria are expressed in broad terms, but are not incompatible with the more detailed criteria established by the International Union for the Conservation of Nature (IUCN 1994), which address attributes affecting the risk of extinction of a species, including rates of decline, distributional range and population size. Particular challenges are faced in identifying threatened vascular plant species due to features of their life history, including variable dispersal range and sessile mature phase (Keith 1998). The inclusion of species with restricted ranges on threatened species lists may be favoured over species with widespread but declining ranges (McIntyre 1992). Despite this, widely distributed plant species which are declining as a result of human activities may be those species which can most effectively be conserved through modification of land-use practices and management (McIntyre 1992).

'Threatened' is often popularly regarded as a synonym of rare. Rarity is an important characteristic of most threatened plant species, which may result in a greater susceptibility to threats. Rabinowitz (1981) identified seven broad forms of natural rarity which a plant species may possess, based on three attributes of a species: geographic range, habitat specificity, and local population size. Species with a small geographic range and narrow habitat specificity (local endemics) are those species most commonly identified as being rare, and often receive a disproportionately high level of conservation attention. In contrast, less attention is given to those species with small geographical ranges and wide habitat specificity, or to species with large geographical ranges and narrow habitat specificity. Finally, some species are common in certain areas but may be seen to display aspects of rarity in other areas. The rarer populations may represent unique genotypes (Cropper 1993), and form an important component of biodiversity worthy of conservation (listing an endangered population is an appropriate mechanism provided for by the *Threatened Species Conservation Act 1995*). Threatened flora fall into the various forms of rarity, however the rarest species may not necessarily be those at the greatest risk of extinction. Rabinowitz's (1981) typology addresses rarity as a spatial phenomenon; rarity can also have a temporal component, as when species are associated with particular seral stages of vegetation development.

The present rarity of a species may be contributed to by evolutionary, biological and anthropogenic factors. A species may be rare if it is an old or 'relic' species which has existed for a relatively long evolutionary time, or if it is a developing or 'new' species which has only recently become distinct. In some cases, rarity can be an advantage to a plant species, making it difficult for herbivores and pathogens to find it (Rabinowitz 1981).

A number of factors contribute to the extinction of plant species on large land masses (Muir 1990), however recent attention has focused largely on the anthropogenic threats to plant species. The following factors are generally considered as important human-based threats to the conservation of plant species in NSW: land clearance for agriculture, grazing, forestry, road works, urbanisation, industrial development, altered fire regimes, spread of exotic species, land degradation, pollution, pathogens, and illegal collection (EPA 1995, Leigh et al. 1984, Boyd 1989, Benson 1991a).

Of these, agriculture presents a major threat to many plant species, due primarily to the large land area involved, and the intensive nature of agricultural activities. Species which are restricted to limited vegetation types are most affected when those vegetation types are cleared for purposes such as cropping or improved pasture (Muir 1990). Introduced herbivores also pose significant threats to plant species, as they may not only cause direct damage to plants, but can also create indirect negative effects such as soil degradation (Muir 1990). For example, the European rabbit (*Oryctolagus cuniculus*) was identified by Auld (1990) as the most significant threat to the threatened plant *Acacia carnei*.

Once a species becomes rare, three major stochastic factors can contribute to increasing the probability of its extinction. These are demographic, genetic, and environmental stochasticity (Gilpin & Soule 1986). A small population faces an increasing risk of extinction from these three types of random factors.

Until recently there was little protection for threatened plant species outside conservation reserves in NSW. The *Threatened Species Conservation Act 1995* provides mechanisms to protect threatened species throughout the state, and the Schedules to the Act provide a catalogue (albeit incomplete) of threatened flora. The schedules of the Commonwealth *Endangered Species Protection Act* (and its successor the *Environment Protection and Biodiversity Conservation Act*) as well as the lists of Rare or Threatened Australian Plants (ROTAP) (Briggs & Leigh 1995) also include NSW species, but the lists are not identical, the differences reflecting both the different contexts of the lists and variation in the processes of compilation.

The compilation of the schedules for the *Threatened Species Conservation Act 1995* permits an analysis of the threatened flora of NSW. Are threatened flora uniformly distributed across the state, or are they concentrated in particular regions or habitats? Are some taxonomic groups more likely to contain threatened taxa than others? The result of such an analysis may have relevance to developing strategies for reserve selection, and for prioritising management of threatened species.

The study presented here examines ecological and biogeographical attributes of the threatened flora of NSW as listed in Schedules 1 and 2 of the *Threatened Species Conservation Act 1995*, and compares these attributes to those of the entire indigenous flora of NSW. The attributes examined are the distribution of the threatened flora in the Botanical Divisions of NSW (Anderson 1947), the distribution of the threatened flora among plant communities in NSW, the taxonomic distribution of the threatened flora at genus and family level, and the distribution of the threatened flora with respect to habit or growth form.

Methods

This study examines the flora listed as threatened under the NSW *Threatened Species Conservation Act 1995*, as of November 1998. Under the *Act*, threatened species fall into two categories: Endangered species (in immediate danger of extinction) which are listed in Schedule 1, and Vulnerable species (at risk of becoming endangered) which

are listed in Schedule 2 of the *Act*. Inclusion on the Schedules is based on distribution, abundance, and threats within NSW; in some cases assessment at a national scale differs from that at the state level. Threatened species may be rare in a NSW context by being at the edge of a wider geographic distribution. For example, 44% of the threatened plant taxa in NSW occur in other Australian states. The definition of species for the purposes of the *Threatened Species Conservation Act 1995* is not a strictly taxonomic one, so that some entities listed are currently undescribed, and others are taxa below species rank.

Information regarding the taxonomy, regional distribution, habit, and occurrence within communities was recorded for each of the threatened plant taxa, as well as for all of the indigenous plant species of NSW. These data were taken from the *Flora of New South Wales* (Harden 1990–1993). Where taxa listed as threatened in the schedules of the *Threatened Species Conservation Act 1995* were not described in the *Flora of New South Wales*, additional reference material was used (including Cunningham et al. 1981, Jacobs & Pickard 1981, Carolin & Tindale 1993, and NSW Scientific Committee determinations).

Species listed under the *Threatened Species Conservation Act* 1995 as presumed extinct (not recorded for more than 50 years despite directed searches) were also examined with respect to features such as former distribution and habit. Again, this information was obtained largely from the *Flora of New South Wales* (Harden 1990–1993).

The *Flora of New South Wales* (Harden 1990–1993) records species distributions in the botanical divisions established by Anderson (1947) (Fig. 1). The regions used in the analysis are therefore different from the IBRA (Interim Biogeographic Regionalisation of Australia (Thackway & Cresswell 1995)) regions which are formally recognised as regions for the purposes of the *Threatened Species Conservation Act 1995*. The IBRA regions were not used in this study as data on plant distribution within IBRA regions are incomplete. The Botanical Divisions, while large, are variable in size. Unfortunately, data are not consistently available at a finer scale to permit analysis comparable to that of Merren (1999) for the British flora.

An analysis of the distribution of National Parks and Nature Reserves in the Botanical Divisions of NSW was also conducted. The area and proportion of each region covered by National Parks and Nature Reserves within the Botanical Divisions were determined using information on the area of each National Park and Nature Reserve (NSW NPWS 1999).

Statistical analysis was mainly carried out by chi-squared analyses using contingency tables, comparing the observed attributes of the threatened flora to the values expected from those of the entire indigenous flora of NSW. Linear regressions were conducted using the statistical package MINITAB (1991).

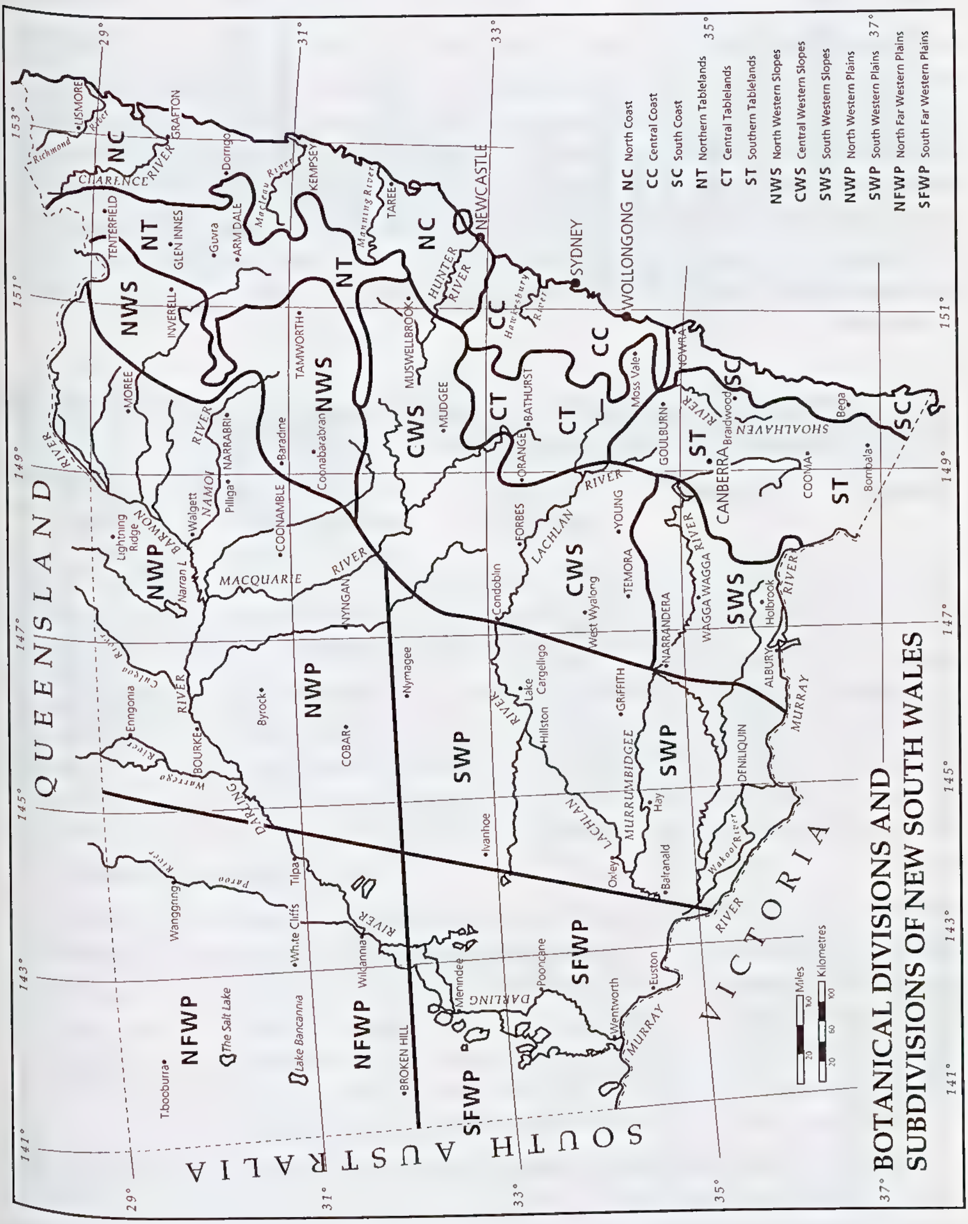

Fig. 1. The Botanical Divisions of New South Wales established by Anderson (1947) and used in the *Flora of New South Wales* (Harden, 1990–1993).

Results

Regional Analysis

Of the 5233 indigenous plant taxa in NSW, 433 (8.3%) were listed as threatened as of November 1998. Of the plant species listed as threatened, 236 were listed as Endangered and 197 as Vulnerable. The North Coast division of NSW contains the highest number of indigenous plant species (2510), as well as the highest number of threatened plant species (140) (Table 1). The Central Coast division also contains a large number of plant species (2098 total with 90 threatened), while the South Western Slopes contain the lowest number of threatened plant species (773 total with 16 threatened). The most striking aspect of this analysis is the greater numbers of both total indigenous and threatened plant species in eastern NSW compared to the west of the state.

Table 1. The number of indigenous plant taxa in each of the Botanical Divisions in NSW, plus the area of each division. Note that a species may occur in several divisions.

Division	All species	Threatened species	Proportion of species threatened (%)	Area of Division (km^2)
SC	1577	33	2.1	11 750
CC	2098	90	4.3	16 575
NC	2510	140	5.6	55 575
ST	1646	56	3.4	40 200
CT	1698	62	3.7	21 800
NT	1560	47	3.0	26 675
SWS	773	16	2.1	28 200
CWS	1428	33	2.3	73 625
NWS	1259	25	2.0	44 381
SWP	1034	23	2.2	112 200
NWP	1326	26	2.1	148 425
SFWP	671	24	3.6	73 475
NFWP	909	31	3.4	119 480

The Central Coast and North Coast divisions were found to have a significantly greater number of threatened species than expected (Fig. 2). Significantly fewer threatened plant species than expected were found in the South Coast, South Western Slopes, Central Western Slopes, North Western Slopes, South Western Plains and North Western Plains.

A markedly different trend is evident in the distribution of plant species presumed extinct (Fig. 2). Equal numbers of species presumed extinct occurred in the South Far Western Plains and the North Far Western Plains as also occurred in the Central Coast

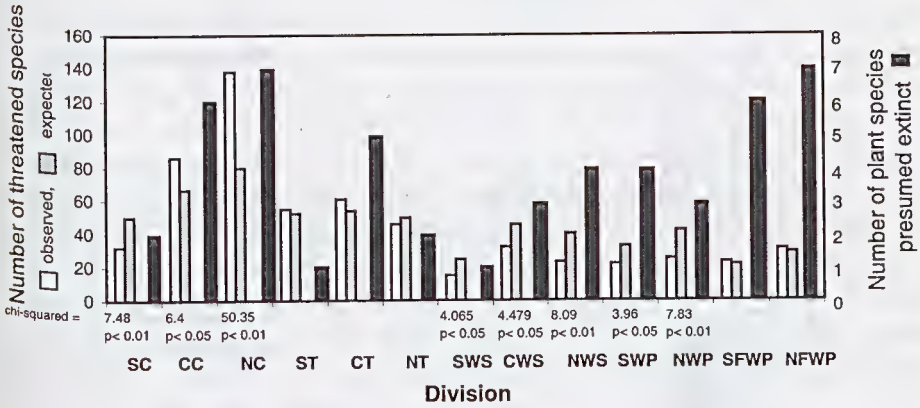

Fig. 2. The occurrence of threatened plant taxa and the former occurrence of plant taxa presumed extinct within NSW. For threatened plant taxa, the expected distribution is also shown with the χ^2 values and the p-values given for those divisions which show a significant difference between the observed and expected occurrence.

and the North Coast. A large number of plant species presumed extinct occurred in the Western divisions, with the least number of plant species presumed extinct having occurred in the Southern Tablelands and South Western Slopes.

Threatened plant species in NSW were found to be restricted in their geographical distribution (Fig. 3a). A significantly greater proportion of threatened species occur in only one division than for all species in NSW. Although there were similar proportions of plant species occurring in two divisions, the proportion of plant species occurring in more than two divisions was significantly smaller for threatened plant species than for all the indigenous plant species in NSW.

In comparing the distribution of the Endangered flora to that of the Vulnerable flora (Fig. 3b), a significantly larger proportion of Endangered plant species was found to occur in only one division, while a significantly smaller proportion of Endangered species occurs in two divisions. There are also some differences in the distribution of Endangered and Vulnerable plant species throughout the Botanical Divisions of NSW. However, it is misleading to compare the numbers of Vulnerable and Endangered plant species occurring in each division separately, as a greater proportion of Vulnerable plant species occur in more than one division (Fig. 3b).

National Parks and Nature Reserves within NSW were distributed unevenly between divisions (Fig. 4). The Central Coast has the largest proportion of its area protected in National Parks and Nature Reserves (over 45%). The western divisions of NSW have smaller proportions of their areas protected in National Parks and Nature Reserves than do those in the east. (Note that these data are subject to change as new protected areas are declared — Fig. 4 does not include new areas of parks and reserves very recently proclaimed in the east of the state as a result of the Regional Forest Agreements).

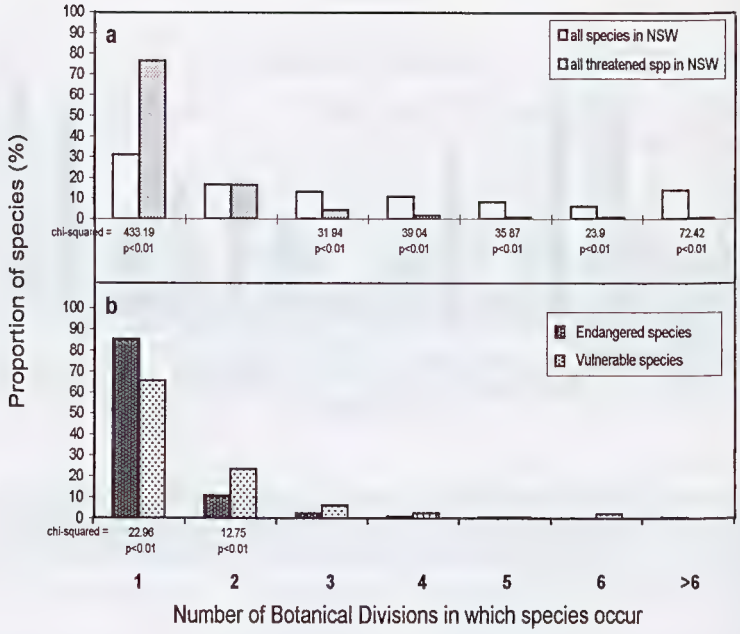

Fig. 3. The proportion of species that occur in a given number of Botanical Divisions for: (**a**) all indigenous plant species in NSW and all threatened plant species in NSW, and (**b**) all Endangered plant species and all Vulnerable plant species in NSW. The χ^2 values and the p-values are given where there is a significant difference between: (**a**) the proportion of all indigenous plant species in NSW and all threatened plant species in NSW, (**b**) the proportion of Endangered plant species and Vulnerable plant species in NSW.

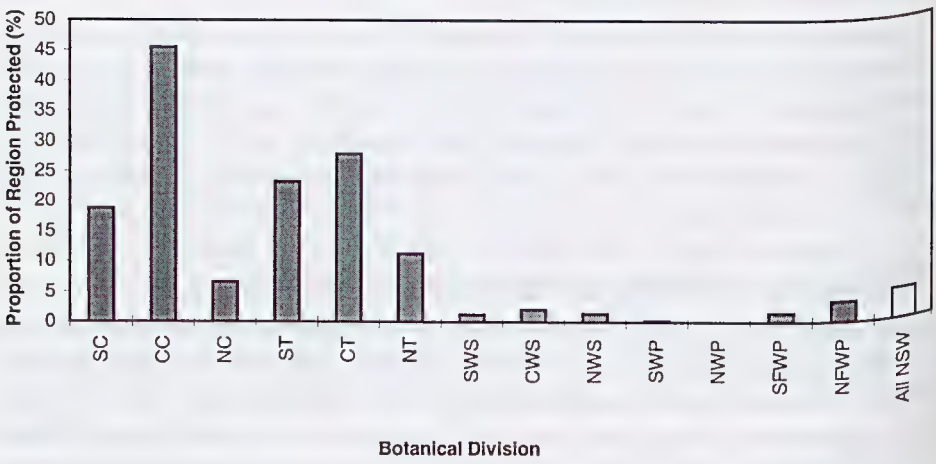

Fig. 4. The proportion of each Botanical Division in NSW protected as National Parks and Nature Reserves (from NPWS 1999). Also shown is the total proportion of NSW which is protected by National Parks and Nature Reserves.

Community Analysis

The analysis of the distribution of plant species in NSW with respect to the community they occur in was limited by a lack of detailed information. The community types listed in the Flora of NSW (Harden 1990–1993) are few in number, and it is uncertain whether there was consistency between authors of different sections. In the case of species in western NSW no community information was provided in many instances. Accepting these limitations, the greatest numbers of threatened plant species are found in sclerophyll woodland, subtropical rainforest, all types of sclerophyll forest, and heath (Fig. 5). When comparing the observed distribution of threatened plant species to that expected, *Nothofagus* rainforest, sclerophyll woodland, dry sclerophyll woodland, wet heath, and arid zone communities all had significantly greater numbers of threatened plant species than expected while temperate rainforest, swamp, and coastal communities had significantly fewer.

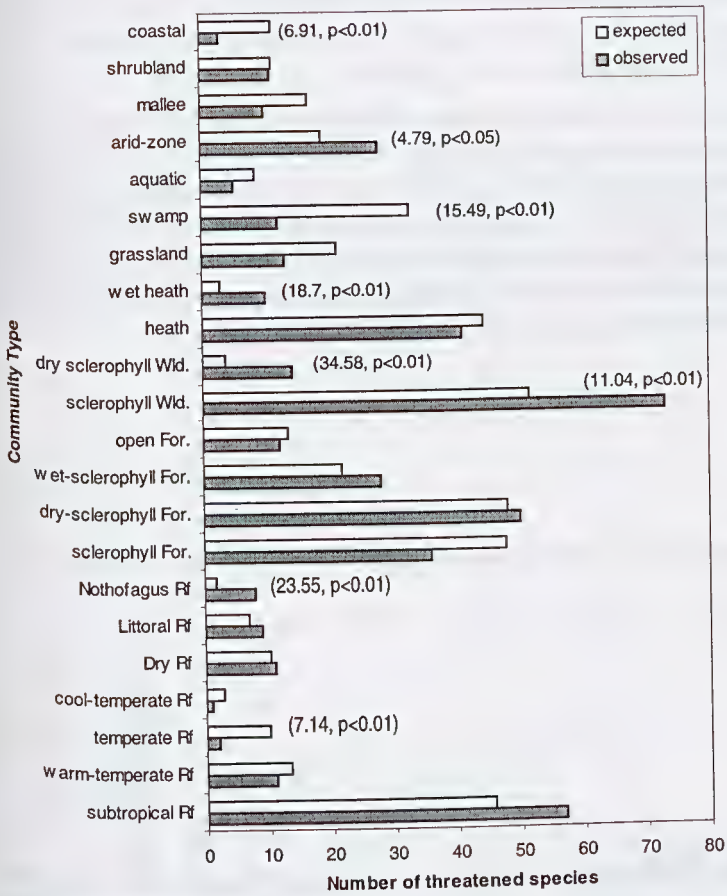

Fig. 5. The occurrence of threatened plant species in NSW in different ecological communities using the terminology of Harden (1990–1993) (note: For. = forest, Rf = rainforest, Wld = woodland). The expected distribution of threatened plants in regards to community type is also shown, with the χ^2-values and p-values for those communities which show a significant difference between the observed and expected distributions of threatened plant species.

Taxonomic Analysis

Most families which contain threatened flora possess only one threatened plant species (Fig. 6), with decreasing numbers of families containing increasing numbers of threatened plant species. In total, 41% of the 215 plant families in NSW contain threatened plant species. However, 53% of the 433 threatened plant species in NSW occur in only six families; Fabaceae, Myrtaceae, Proteaceae, Orchidaceae, Rutaceae and Asteraceae (Table 2). Significantly more threatened plant species than expected occur in the families Myrtaceae, Proteaceae, Rutaceae, Lamiaceae and Casuarinaceae. In contrast, the Asteraceae, Poaceae and Cyperaceae contain significantly fewer threatened plant species than expected.

The distribution of threatened plant species by genera shows a similar trend to that of the family distribution, but an even greater proportion of genera containing threatened plant species possess only one threatened species (Fig. 7). Threatened plant species occur in 18% of the 1132 genera in NSW, while 20% of the threatened plant species in NSW occur in just four genera (*Eucalyptus* (sensu lato), *Acacia*, *Grevillea*, and *Zieria*) (Table 3). Of these, *Eucalyptus*, *Grevillea* and *Zieria* were found to contain significantly more threatened species than expected.

Linear regression showed that the proportion of threatened species in a family was not significantly related to the size of the family (F-value = 0.04, p = 0.85). The lack of a linear trend can be attributed to the large variation in the proportion of threatened species in the smaller families. In contrast, the proportion of threatened species in the larger families remained around 8%, the average proportion of threatened species in all families in NSW. There was also no significant relationship between size of genus and proportion of threatened species (F-value = 0.70 , p = 0.403).

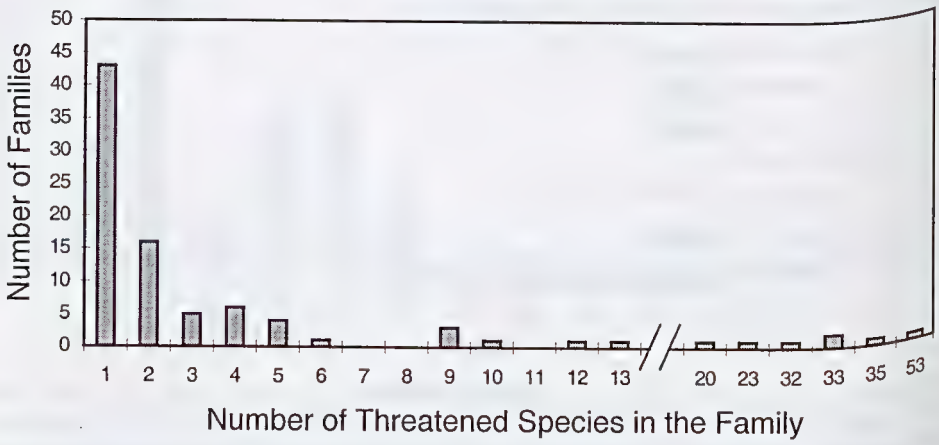

Fig. 6. The distribution of threatened plant species in NSW by family. Note that the *x*-axis is not continuous.

Table 2. The families with 5 or more threatened plant species in NSW. Also shown are the size of the family, the proportion of the family which is threatened, and whether that family has significantly more or fewer threatened plant species than expected.

FAMILY	Number of threatened species	Total number of species	Proportion of species threatened (%)	Significance	χ^2	P-value
Fabaceae	56	547	10.2	n.s.	3.168	> 0.05
Myrtaceae	53	443	12.0	sig. more	8.675	< 0.01
Proteaceae	35	181	19.3	sig. more	30.215	< 0.01
Orchidaceae	33	333	9.9	n.s.	1.255	> 0.1
Rutaceae	33	156	21.2	sig. more	35.130	< 0.01
Asteraceae	20	413	4.8	sig. fewer	6.949	< 0.01
Lamiaceae	13	86	15.1	sig. more	5.383	< 0.01
Euphorbiaceae	12	103	11.7	n.s.	1.581	> 0.1
Poaceae	10	411	2.4	sig. fewer	20.055	< 0.01
Epacridaceae	9	96	9.4	n.s.	0.157	> 0.1
Rhamnaceae	9	62	14.5	n.s.	3.247	> 0.05
Chenopodiaceae	9	180	5.0	n.s.	2.608	> 0.1
Brassicaceae	6	52	11.5	n.s.	0.747	> 0.1
Casuarinaceae	5	24	20.8	sig. more	5.036	< 0.05
Cyperaceae	5	243	2.1	sig. fewer	12.971	< 0.01
Thymeleaceae	5	45	11.1	n.s.	0.489	> 0.1

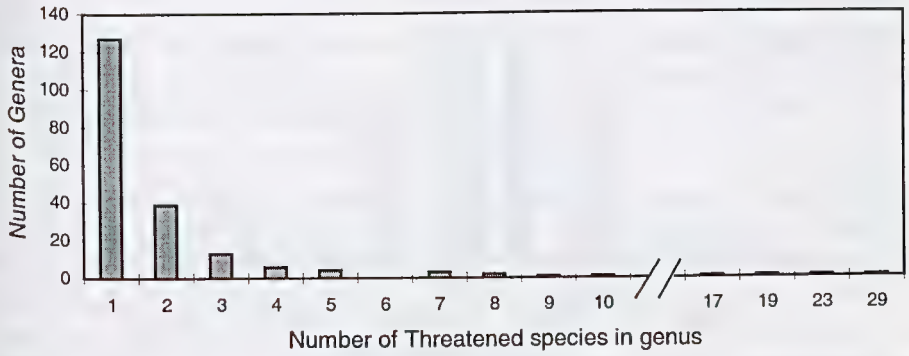

Fig. 7. The distribution of threatened plant species in NSW by genus. Note that the *x*-axis is not continuous.

Table 3. The genera with the greatest number of threatened plant species in NSW.

	Number of threatened spp	Total number of species	Proportion of species threatened	Significance	χ^2	P-value
Eucalyptus	29	235	12.3%	sig. more	5.366	< 0.025
Acacia	23	217	10.6%	n.s.	1.609	> 0.1
Grevillea	19	53	35.8%	sig. more	53.556	< 0.01
Zieria	17	33	51.5%	sig more	81.834	< 0.01

Growth Form

The analysis of the growth form (or habit) of threatened plants in NSW shows that the largest number of threatened plant species are trees or shrubs, with herbs being next most abundant, and only a small number of threatened plant species being ferns or climbers (Fig. 8). Significantly more threatened plant species than expected were trees/shrubs, while significantly fewer threatened plant species were herbaceous. However, there were many more herbaceous plants presumed extinct than either trees or shrubs (Fig. 8).

Discussion

Regional Analysis

Currently listed threatened plant species in NSW are markedly restricted in their range when compared to all plant species in NSW, with more than 75% of threatened species occurring in only one Botanical Division. Within the 'threatened' category, Endangered species are more restricted in their distribution than Vulnerable species. Thus most species listed as threatened in NSW display the rarity types identified by

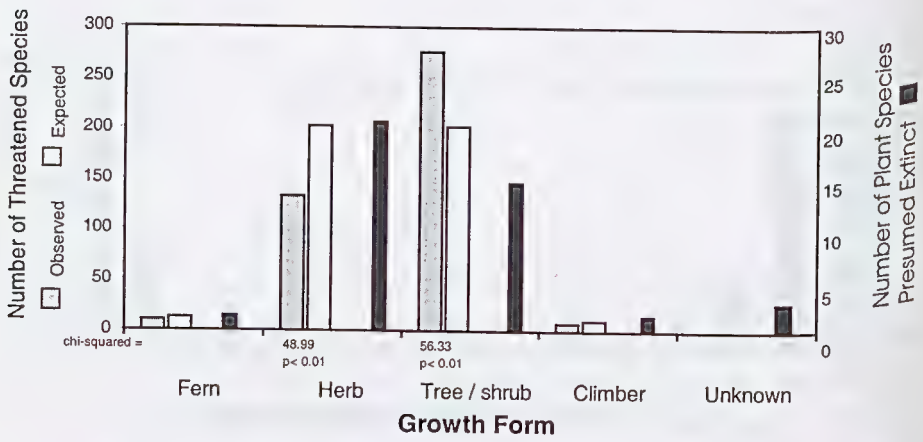

Fig. 8. The occurrence of threatened plant species and plant species presumed extinct in NSW, with respect to growth form.

Rabinowitz (1981) involving small geographic ranges and narrow habitat specificity, typical of local endemics. This may indicate that either locally endemic species are the most prevalent type of rare plant and that they experience the greatest degree of threat, or that there is a predisposition to list species which show the most obvious signs of being geographically restricted or threatened.

The schedules of the *Threatened Species Conservation Act 1995* do appear to be deficient in their listing of Vulnerable plant taxa in comparison to Endangered taxa. Most states and countries list about twice as many Vulnerable species than Endangered species, whereas in NSW there are 39 more Endangered species listed than Vulnerable species. The ROTAP list has 301 Endangered species and 708 Vulnerable species (6% and 14% of the national vascular flora respectively) (Briggs & Leigh 1995). The process by which the initial schedules of the *Threatened Species Conservation Act 1995* were created favoured identification of Endangered species, and nominations since the proclamation of the *Act* have not redressed the balance.

On a regional basis, the North Coast and Central Coast contain the most threatened plant species, while the South Western Slopes contains the fewest. A larger number of species and threatened species occur in the eastern divisions (the Coast and Tablelands) than occur in the western divisions (the Western Slopes, Plains, and Far Western Plains) (Fig. 2). Taking into account the different size of each division by examining the regional distribution on a species per area basis, the eastern divisions, such as the Central Coast and the Central Tablelands, contain much higher threatened species densities than the western divisions. Lunney et al. (1997) found that the North Coast region of NSW also contained the highest number of threatened vertebrate species. However, the western region of NSW was found to contain the largest number of threatened mammals in total (Lunney et al. 1997) and the largest number of threatened rodents (Dickman et al. 2000).

Not only do the North Coast and the Central Coast support the most threatened plant species, they also contain more threatened plant species than expected. In contrast, the South Coast, South Western Slopes, Central Western Slopes, North Western Slopes, South Western Plains and the North Western Plains all contain significantly fewer threatened plant species than expected. The trend for there to be significantly more than expected threatened plant species in the eastern divisions and significantly fewer than expected in the western divisions may be due to a number of factors. These include the level of botanical study conducted in each division, the sizes of the geographic ranges of species, the level of threats present in each division, and the degree of environmental heterogeneity in each division.

The larger number of species (threatened and non-threatened) in the eastern divisions may reflect the greater environmental complexity and, in general, more favourable climatic conditions for plant growth compared to the inland. The eastern divisions include habitat from sea level to high peaks (by Australian standards), and high rainfall and locally high nutrient conditions provide habitats for sclerophyll forest and rainforest communities which are absent further west (Adam 1987). The absence of a relationship between the size of the regional flora and regional area (Fig. 9) supports the hypothesis that habitat diversity is important in determining patterns of species

richness. The high species richness of the South Coast and Central Coast divisions in a national context was emphasised by Keith, Miles and Mackenzie (1999).

While environmental factors may explain the distribution of species richness, how might the greater proportion of threatened taxa in the east of the state be explained? One possible explanation is that there is a greater degree of threat (real or perceived) in the east of the state. Both the North and Central Coasts have experienced significant impacts since European settlement. The Central Coast faces continued pressure associated with the growth of the greater Sydney metropolitan area, while the North Coast lowlands were extensively cleared for agriculture and face continued pressure from coastal development. However, the divisions which have been most extensively affected by human land use are the flatter areas of the Western Slopes and the eastern portion of the Western Plains (Benson 1991b). Benson (1991b) regards the major threats to plant species in NSW as grazing and cropping, which are primarily carried out in the mid west (cropping) and the far west (grazing) of the state.

The NSW wheat belt occupies approximately 22.5% of the state (Sivertsen 1994) (the Western Slopes and the Western Plains) of which roughly 90% has been cleared of native vegetation (Biodiversity Unit 1995). This clearing may be reflected in the number of plant species presumed extinct from the Western Slopes and Plains. Sivertsen (1994) showed that significant levels of clearing of native vegetation is continuing to occur in the wheat belt of NSW, maintaining a level of threat to the remaining native flora.

The Western Plains of NSW have been grazed extensively since the 1830s (Benson 1991b). Benson (1989) reported that grazing has affected more than 60% of NSW, and has resulted in major reductions in the abundance of plant species and has been implicated in a number of extinctions. Grazing may therefore have contributed to the relatively high number of plant species presumed extinct in the Far Western Plains region, and as the onset of grazing preceded full botanical documentation, a number of species may have become extinct without ever having been recorded.

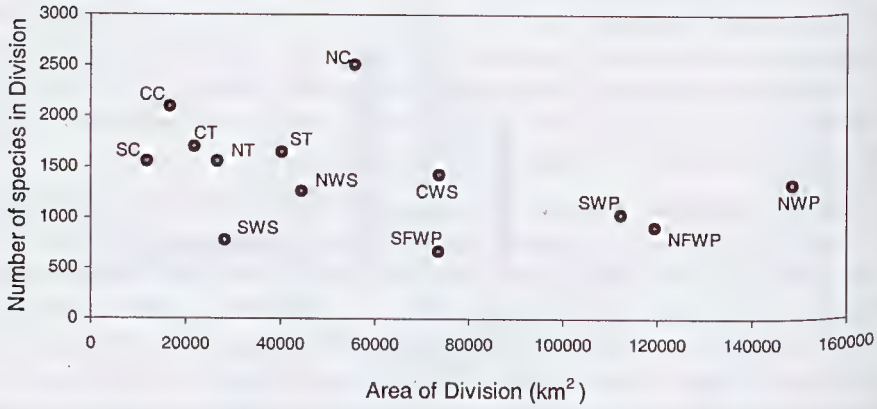

Fig. 9. The relationship between the size of each division and the number of species.

Hence it would appear that, although difficult to quantify, the levels of threat faced by plant taxa are unlikely to be greater in the east than in the west of NSW. Nevertheless, the more intense, localised threats in the east of the state, and their visibility to a much larger number of people, might tend to support a perception of greater and more immediate threat.

A further possible explanation of the skewed distribution of threatened species is that plants on the North and Central Coasts may possess an innate degree of rarity, by virtue of limited geographical distributions and/or small populations. The distinctiveness of north eastern NSW with its representation of northern and southern elements of the flora was recognised by Burbidge (1960) as the Macpherson/Macleay overlap. The high incidence of local endemism, associated with distinctive areas of geology, topography and local climate has been stressed by Adam (1987) and Benson (1991b). Species with geographically restricted distributions may be at greater threat from wide spread disturbance than widespread species. In comparison, the lower levels of local endemism in the west may reflect the more homogenous environment. Burrows (1998) has pointed out that most threatened plant species in the South Western Slopes region are not local endemics, but have a reasonably wide distribution.

A final possibility is that the currently recorded distribution of threatened flora is at least in part an artefact of the intensity of botanical exploration and survey. It is possible that large numbers of plant species have become extinct in the western regions before being taxonomically documented. Certainly there has been much more study in the east of the state, but even in what are regarded as the better explored regions, major finds can still be made (as for example the recent discovery of the Wollemi Pine (*Wollemia nobilis*)). It is difficult to assess the extent to which under-recording or lack of appropriate data have influenced the present composition of the schedules. In the future, as the schedules are subject to amendment, it will be interesting to see whether the proportional representation of western plant species increases.

The distribution of protected areas in the National Parks and Wildlife Service estate also shows a marked bias to the east of the state (Fig. 4). It is known that many species and communities are not represented in the limited reserve areas of the western regions (Pressey 1990, Benson 1999), but it is less clear how adequately the reserve system in the east conserves the threatened flora of these regions. In 1992, Leigh and Briggs estimated that nationally only 48.8% of threatened plant species had some part of their population protected in conservation reserves, and that only 13.7% of these were 'adequately conserved' (it must be noted however that population data for most threatened species are inadequate to properly assess conservation status). Comparable data for the species on the Schedules of the *Threatened Species Conservation Act 1995* are not readily available, however it is notable that many of the species from eastern NSW added to the Schedules since the *Act* came into effect are either inadequately conserved, or not conserved at all.

Community Analysis

Sclerophyll woodland was found to be the community containing the most threatened plant species and possessing many more threatened plant species than expected. This

supports the findings of Leigh and Briggs (1992) who also showed that woodland communities contained the largest number of endangered plant species in NSW. This prevalence of threatened plant species in woodland communities may simply reflect the large area of NSW originally covered by woodland vegetation. Most woodland in NSW has been either cleared or modified under European settlement (Leigh et al. 1984). Where the understory of woodland is composed of herbs and grasses, sheep and cattle have been allowed to graze, often preventing the regeneration of woodland plant species. Alternatively, woodland has been cleared to allow for more vigorous growth of native grasses, or the establishment of crops and improved pasture. For both the vertebrate fauna in general and rodents in particular, woodland also supports the greatest number of threatened species (Lunney et al. 1997, Dickman et al. 2000).

Subtropical rainforest was the community with the next largest number of threatened plant species, and if all rainforest types were grouped together then rainforest would have the largest number of threatened plant species. This agrees with the findings of Leigh and Briggs (1992), and the commonly held view that rainforests possess high species diversity and many threatened species. Rainforest distribution is very fragmented in eastern NSW (Adam 1987), and many rainforest species have very restricted distributions. Rainforests in NSW have been seriously depleted since European settlement, and continue to face significant threats. Approximately 75% of rainforest in NSW has been cleared or disturbed by logging since European settlement, leaving only small remnants of 'virgin' subtropical rainforest in northern NSW (Floyd 1990). Adam (1987) estimated that half of the 250 000 ha of rainforest remaining in NSW is in some way degraded.

Both wetland and coastal communities contain significantly fewer threatened species than expected, despite these communities showing spatially disjunct distributions, being subject to significant threats, and being regarded as of high conservation value. There is a low degree of local endemism in both wetland and coastal communities, and many species have very wide geographic ranges. It is important to recognise that while consideration of threatened species is necessarily an important component of conservation strategies, it cannot be the only one, and that communities of high conservation value (which may satisfy the criteria for listing as Endangered Ecological Communities) need not necessarily provide habitat for threatened species. The widespread distribution of species in habitats such as wetlands does, however, lead to complacency as to their status, and declines may be under-recorded.

Taxonomic Analysis

Most families and genera which contain threatened taxa possess only one or two threatened plant species. However, there are several taxonomic groups which contain a large proportion of the threatened flora. These genera and families were notably the larger ones, and several of the larger genera/families contain significantly more threatened plant species than expected. Of these, the families Proteaceae and Rutaceae and the genera *Zieria* and *Grevillea* contained markedly high proportions of threatened plant species. *Zieria* is an interesting case as many of the taxa acknowledged to be threatened have yet to be formally described. In both *Zieria* and *Grevillea* many of the

threatened taxa are local endemics, suggesting that restricted distribution may be a major threat, or contribute to a perception of threat.

It will surprise many botanists that the number of threatened species in the Orchidaceae is not significantly greater than expected. A large proportion of orchids grow in very specific habitats, such as on particular rock types or as epiphytes on particular tree species. Orchids also require the presence of specific fungi for successful germination and establishment. However, the common notion that orchids are innately rare may simply reflect the views of the large number of orchid enthusiasts.

Asteraceae, Poaceae and Cyperaceae are three large families in which relatively few species have been recognised as threatened. These families are largely herbaceous and are regarded as 'difficult' by many field botanists. Accordingly, under-recording and lack of data may contribute to the apparent paucity of threatened grasses, daisies and sedges. In a study of the threatened flora of the Cape Peninsula in South Africa, Trinder-Smith et al. (1996) also found that the Proteaceae were over-represented and the Asteraceae under-represented. They related this to the different degree of endemism in the families, with the Proteaceae having a high degree of endemism and more threatened species. Local endemism is not a feature of Asteraceae in NSW, so this may also contribute to it possessing a low proportion of threatened species. In the mainland United States, however, the Asteraceae contains a very large number of threatened species (Morse 1996).

Growth Form Analysis

The most noteworthy feature of the growth form analysis was the over-representation of trees/shrubs in the threatened flora, and the under-representation of herbaceous species. An important difference between these two growth forms is the ability for herbaceous species to reach higher densities of individuals compared to shrubs or trees. Despite this, the more palatable plants (e.g. the herbs) are likely to have suffered the most damage from activities such as large-scale grazing. The larger number of herbaceous species presumed extinct (20) compared to trees or shrubs (14) tends to support this hypothesis. However, herbaceous species tend to be under-recorded, so that low overall representation of herbs amongst threatened species may reflect inadequate documentation (as was suggested by McIntyre (1992) for Northern NSW), while a number of the apparently extinct herbs may simply have not been refound.

Conclusions

Both the *Flora of New South Wales* and the Schedules of the *Threatened Species Conservation Act 1995* are works in progress, so the statistics reported in this paper should not be regarded as absolute. The known composition of the flora is likely to change more slowly than the Schedules of the *Act*, although at this stage in our knowledge, newly described taxa will most likely be rare and therefore candidates for recognition as being threatened. Our knowledge of the distribution of taxa improves with collection and survey, so that the distributional data recorded in the flora is being continually updated. Changes to the Schedules of the *Act* will be limited by the

availability of data sufficient for the NSW Scientific Committee to make an assessment, and the nomination process.

Early experience with nominations has been that they reinforce the existing distribution patterns, with a very strong predominance of nominations being from eastern NSW, and particularly the Central and North Coasts (Dickman 1997). The successful nominations satisfy the criteria of the *Act*, so that even in regions which already have a high proportion of threatened taxa, more are still being added. However, it is not clear as yet whether the relatively few additions from west of the Divide are a true reflection of the distribution of threatened taxa, or of the concentration of nominees in the Central and North Coasts. The proportion of the flora which is threatened, currently nearly 9%, is an indication of the magnitude of the conservation challenge facing NSW. The indication from the number of successful nominations for addition to the Schedules is that the 'real' proportion of threatened plant species in NSW will be much higher. If the flora of NSW is similar to those of other states and countries then a very substantial increase in the number of Vulnerable species would be expected (Briggs & Leigh 1995, Groombridge 1994).

The distribution of the threatened flora of NSW shows similarities to that of the threatened vertebrate fauna (Lunney et al. 1997), with both threatened plant and vertebrate species occurring in their greatest numbers in the north-east, and in woodland communities. Adequate conservation reserves in these areas could therefore act to protect large numbers of both threatened flora and fauna. However, differences in regional distribution were noted between the threatened flora and sub-groups of the vertebrate fauna, with more threatened mammals (and amongst mammals, the rodents) occurring in the west of the state. The larger number of presumed extinct taxa in the west of the state is also paralleled amongst vertebrates.

It is important to note that this study deals only with the vascular plants of NSW. Information on the cryptogamic flora is very limited and, as yet, no non-vascular plant species has been listed in the Schedules of the *Threatened Species Conservation Act 1995* (although an Endangered Ecological Community defined by fungi has been listed). This is unlikely to represent the degree of threat to cryptogams, but it is likely to be considerable time before data appropriate to assess the non-vascular flora are available.

Our analysis was limited by the availability of data. Testing for relationships between threat status and ecological attributes of the flora might permit better prediction of categories of species at risk. Ecological attributes which would be interesting to examine include post-fire regeneration strategy, breeding system, pollination mechanisms, seed bank dynamics, mycorrhizal status and soil preferences. A more detailed community classification and more consistent recording of community information would also permit more detailed analysis.

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Vegetation of the Holsworthy Military Area

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French, K., Pellow, B. and Henderson, M.[1] *(Janet Cosh Herbarium, Department of Biological Sciences, University of Wollongong, Wollongong, NSW 2522.* [1]*Current address — Biodiversity Survey and Research Division, NSW National Parks and Wildlife Service, PO Box 1967, Hurstville, NSW 2220. Address for correspondence: Kristine French, Dept of Biological Sciences, University of Wollongong, Wollongong, NSW 2522. email:* kris@uow.edu.au) *2000. Vegetation of the Holsworthy Military Area.* Cunninghamia *6(4): 893–940.*

Vegetation in the Holsworthy Military Area located 35 km south-west of Sydney (33°59'S 150°57'E) in the Campbelltown and Liverpool local government areas was surveyed and mapped. The data were analysed using multivariate techniques to identify significantly different floristic groups that identified distinct communities. Eight vegetation communities were identified, four on infertile sandstones and four on more fertile shales and alluviums. On more fertile soils, Melaleuca Thickets, Plateau Forest on Shale, Shale/Sandstone Transition Forests and Riparian Scrub were distinguished. On infertile soils, Gully Forest, Sandstone Woodland, Woodland/Heath Complex and Sedgelands were distinguished. We identified sets of species that characterise each community either because they are unique or because they contribute significantly to the separation of the vegetation community from other similar communities.

The Holsworthy Military Area contains relatively undisturbed vegetation with low weed invasion. It is a good representation of continuous vegetation that occurs on the transition between the Woronora Plateau and the Cumberland Plain. The Plateau Forest on Shale is considered to be Cumberland Plains Woodland and together with the Shale/Sandstone Transition Forest, are endangered ecological communities under the *NSW Threatened Species Conservation Act 1995*. The Melaleuca Thickets may also be considered part of the endangered ecological community, Sydney Coastal River-flat Forest. As such the area has high conservation significance.

Introduction

Whilst Hawkesbury Sandstone communities are well conserved in the Sydney Region, there are limited areas where shale, riverine and shale/sandstone transition zone communities are protected (Benson 1992). The Holsworthy Military Area comprises 18 000 ha of bushland 35 km south-west of Sydney in the Campbelltown and Liverpool local government areas (33°59'S 150°57'E). It is bordered by Heathcote National Park and the Woronora water catchment area in the east, Dharawal State Recreation Area to the south and suburban areas to the west and north (Holsworthy Vegetation Map). The Military Area occurs largely on the Woronora Plateau that is gently sloping and shows a sharp decline in rainfall from east to west. The remaining area to the north is

part of the Cumberland Plain with shale and tertiary alluvium communities contrasting with the mostly woodland vegetation on Hawkesbury sandstone on the Woronora Plateau. The Military Area covers the boundary between sandstone, shale and Tertiary alluvium and remains one of the few areas in Sydney where this type of transitional vegetation can still be found undisturbed. Prior to this study, there was limited knowledge and understanding of the conservation significance of Holsworthy Military Area.

In response to an increased need to manage their lands in a more ecologically sensitive manner, the Department of Defence undertook the development of a Plan of Management in 1995 (Axis Environmental & Australian Museum Business Services 1995a, 1995b). This paper uses the data from the vegetation audit that formed the basis of the flora section within this Plan of Management. Shortly after the Plan of Management was developed, the area was considered for a second airport for the Sydney Region and part of the area was surveyed again (Biosis Research & PPK 1997). However, the Military Area remains largely unknown and regional maps show either little information or base their interpretation on aerial photographs and limited ground-truthing (Benson & Howell 1990a, Benson 1992, James 1997). This paper, therefore, makes a significant contribution to the knowledge of these vegetation communities and their significance in the Sydney Region.

Plant diversity encompasses species at all strata and yet communities are often classified by management agencies on the basis of larger shrubs and canopy trees to simplify identification. Disturbed areas, such as grazed woodlands, may frequently have canopy and large shrub species present although the other plant species may have vanished. Such a loss of diversity represents a significant change in biological diversity and a management problem that can go unnoticed because of the focus on the canopy and larger shrubs. Furthermore, classification of vegetation communities can result in vague distinctions between similar communities with little understanding of what species (understorey and canopy species) are characteristic of particular communities (French et al. 2000). A more precise characterisation of vegetation communities would enhance management and conservation of many areas, despite the obvious variability that exists from site to site. Whilst a range of possible techniques could be used, we have investigated the use of one method using multivariate techniques.

The aims of the study were to:

1. map the main vegetation types in the area using API,
2. identify distinct vegetation units through multivariate analysis and associate these with identifiable map units,
3. identify a suite of species that characterise each vegetation community,
4. identify exotic species and species of conservation significance.

Methods

Mapping

Vegetation boundaries were initially mapped using aerial photographs. Vegetation was distinguished on the basis of height and cover of the tallest stratum. Six vegetation types were distinguished from the aerial photo interpretation (API) using differences in tonal texture. These API map units were: 1. Melaleuca Thickets, 2. Plateau Forests, 3. Gully Forest, 4. Sandstone Woodlands, 5. Heaths and 6. Sedgelands.

Riparian vegetation on sandstone only occurred along the edges of creeks and rivers in bands too narrow to map. The area of land occupied by this portion of the riparian vegetation type could not be estimated but was small.

Vegetation was plotted on a TOPCON 2000 stereoplotter and transferred to ERMS (National Parks and Wildlife Service) for editing. The TOPCON plotter was used to plot the vegetation boundaries digitally and rectify them to the Australian Map Grid, reducing distortion apparent in aerial photography.

Ground surveys

Seventy-three sites were surveyed from October 1994 to April 1995. Sites were stratified by parent material, topography and vegetation structure. Sites were spread throughout the study area to obtain a representative survey of the area and attempts were made to survey vegetation in accordance with the proportion of the total area each vegetation type represented. Extra sites were surveyed on shale, as these are likely to be regionally important due to extensive clearing throughout the Sydney Basin. Sites were named according to the range (Department of Defence classification) where they occurred, i.e. 12B was a site in B range. Sites and ranges are incorporated into the vegetation map of Holsworthy.

The survey design followed a method used by NSW National Parks and Wildlife Service (e.g. Keith 1994). At each site, a 20 m × 20 m quadrat was established. All vascular plant species within this quadrat were identified and recorded. An abundance measure was assigned to each species based on a Braun-Blanquet scale in Poore (1955) (Table 1). Details of grid references, physiography, soil, disturbance, horizontal elevation and vegetation structure were recorded at each site (Table 2). All sites were digitised onto a map according to the Australian Map Grid Reference. Species were either identified in the field or specimens were collected for identification in the Janet Cosh Herbarium, University of Wollongong or National Herbarium of NSW, Sydney. Voucher specimens of some species are held at the Janet Cosh Herbarium, University of Wollongong. Nomenclature was according to Harden (1990–1993) and Jacobs and Everett (1996).

During the surveys, exotic species were recorded at sites and at other locations visited opportunistically within the area. Species that are rare and threatened were recorded using Briggs and Leigh (1995). Other locations where these species were found were also recorded opportunistically.

Table 1. Values used to record cover/abundance of species in survey sites.

Cover Abundance Value	Description
1	one–a few individuals
2	uncommon and < 5% cover
3	common and < 5% cover
4	very abundant and < 5% or 5–20% cover
5	20–50% cover
6	50–75% cover
7	75–100% cover

Based on Braun-Blanquet scale (Poore 1955).

Table 2. Environmental information recorded at each site.

Environmental Feature	Description	Scale
Map name/scale	1:25 000 map reference	
Location	description using roads, creeks	
AMG Reference	grid reference description	
Physiography	description of site	
Slope	using clinometer	0–90°
Aspect	compass direction	
Elevation	from topographic map	
Soil drainage	subjective assessment	well drained (dry or moist)–water-logged
Soil texture	compared to standard samples	clay/loam/sand
Soil depth	subjective assessment	deep/shallow/skeletal
Geology	based on site inspection	
Horizontal elevation	horizontal azimuths taken at 8 compass points using a compass and clinometer	
Disturbance	Description of type of disturbance	grazing, logging, clearing, erosion, exotic plants and animals
Previous fire history	subjective assessment of signs	
Structure	height, cover and dominant species of major structural levels	trees/shrubs/ground

This information is based on the standard information collected by NSW NPWS (Keith & Sanders 1990).

Analysis of vegetation communities

Multivariate analyses were used to identify floristic groups using the PRIMER package (Carr 1994). Similarity matrices were calculated using the Bray-Curtis index and clustered using group averages on untransformed data. This analysis grouped sites according to their similarity in species composition and abundance. An ordination analysis was undertaken using non-metric multi-dimensional scaling (MDS) to enable visual interpretation and confirmation of major groupings identified in the cluster. Floristic groups are fundamentally based on these two analyses, with some further interpretation from investigating the field notes for each site.

For each floristic group identified, an Analysis of Similarity (ANOSIM) was undertaken to determine if this grouping was significantly different statistically to similar adjacent groups (in the ordination and cluster) and whether it formed a unique vegetation community. To do this, two closely related communities were combined into a new dataset on which an ANOSIM was performed on all species. For all vegetation communities thus identified, an average similarity was calculated and the set of species contributing up to 50% of this similarity within the community identified (SIMPER module). These species, therefore, form the dominant suite of species that identify this community and provide an explicit mechanism for describing vegetation communities. For vegetation communities that are closely related, this analysis also identifies the species that contribute up to 50% of the differences between the two vegetation communities which aids in interpreting the main features that differ between communities. SIMPER analysis can only be performed when species lists are below 160 species and the SIMPER analysis was performed on reduced datasets. Rare species or species whose cover abundance was extremely low will not contribute very much to similarities or differences because the Bray-Curtis measure takes into account abundance as well as presence. Thus, commonly occurring species, or species with high levels of cover, are the species which contribute most to the Bray-Curtis values. The dataset was first reduced by excluding species which only occurred at one site in low abundance (1 or 2) or at two sites (both at abundance level 1). In most cases this reduced the species list to below 160. However, for the comparison between Transition Forests and Gully vegetation, species that occurred at three sites (at abundance level 1) were removed as well. Species that were unique to vegetation communities were identified separately as these species may also be characteristic of communities. This duel approach allowed the inclusion of rare species in characterising communities as well as identifying species on the basis of Bray-Curtis similarity measures.

Results

Vegetation communities

The cluster analysis and ordination distinguished eight vegetation groupings (Figs 1, 2, Table 3). In general, groupings followed soil types and the water-holding capacity of the soils, such that most communities could be aligned with the API and with field notes (Table 2). Four of these groups occurred on more fertile soils (deep sandstones,

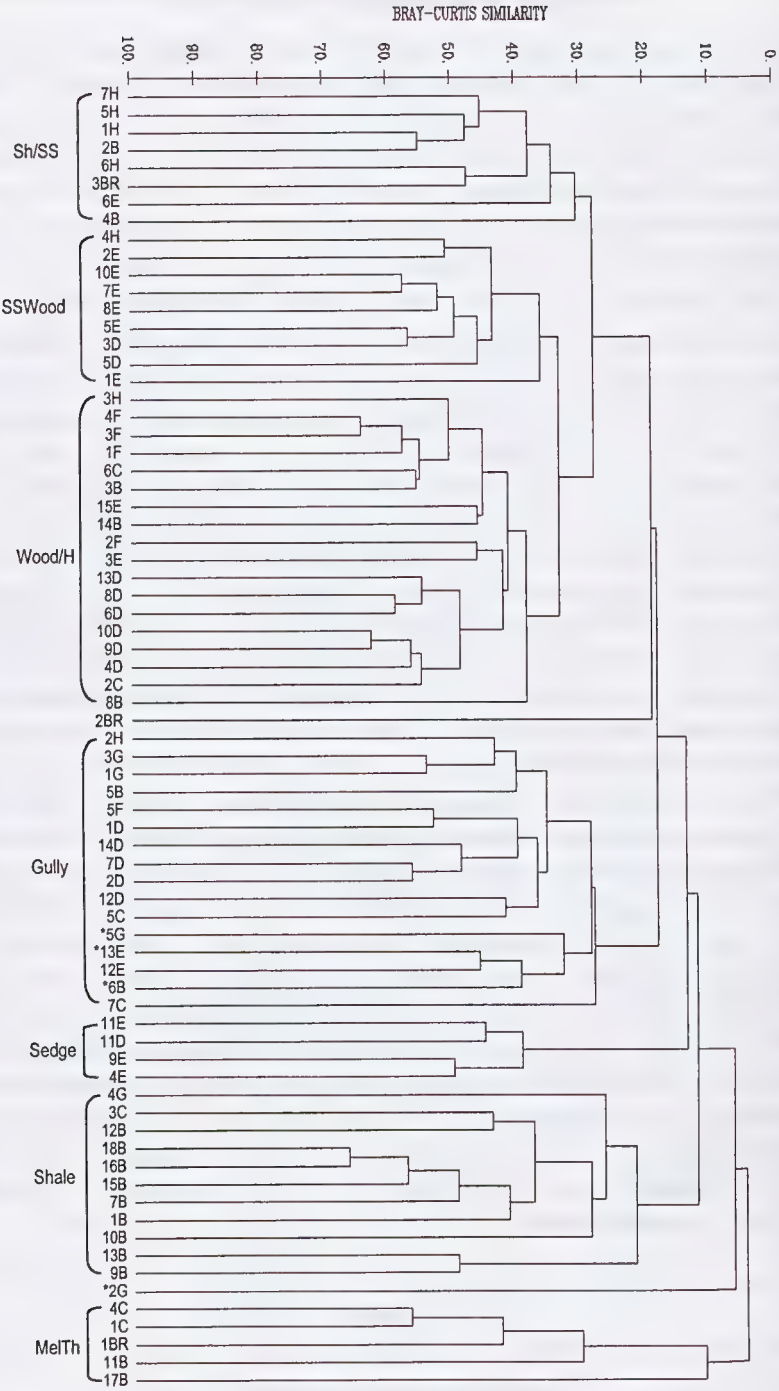

Fig 1. Cluster analysis of 73 sites surveyed in Holsworthy Military Area. Analysis was performed using Bray-Curtis similarities and group averages (PRIMER package, Plymouth Marine Laboratories). Sh/SS = Shale/Sandstone Transition Forest, SSWood = Sandstone Woodland, Wood/H = Woodland/Heath Complex, Gully = Gully Forest, Sedge = Sedgeland, Shale = Plateau Forest on Shale, MelTh = Melaleuca Thicket. Sites marked with an asterisk are Riparian Scrub. The classifications are based on cluster and ordination analysis, field note interpretations and analysis of similarity (see text).

shales and alluvium) and four communities were identified on less fertile, shallow sandstones (Figs 1, 2). Overall, 452 species were recorded in the study area, 414 native species and 38 exotic species. Exotic species at all but a few sites were in low abundance (Table 4).

Vegetation Community: Melaleuca Thicket

Alluvium sites with *Melaleuca linariifolia* and *Eucalyptus botryoides/saligna* complex were separated clearly from the rest (Figs 1, 2). These sites had a dense canopy with a thick sedge groundcover and occurred along some creek beds in the northern part of the area. They were significantly different from the nearest vegetation type in the ordination, Plateau Forests on Shale (ANOSIM: Global R = 0.951, $p < 0.001$) but variability within the sites was larger than other groupings with an average similarity (Bray-Curtis) of only 34% (reduced by 43% from a common dataset with Shale). Analysis identified only four species contributing 50% of the similarity amongst sites (Table 5). Despite the small number of sites sampled, 102 species were recorded. Forty-five species were unique to this vegetation community (44% of species found in this community). Only seven of these occurred in more than one quadrat (Table 6). Site 17B was most different from the rest being dominated by *Eucalyptus botryoides/saligna* in the canopy with no *Melaleuca linearifolia* and a significant cover of *Ligustrum lucidum*. This vegetation community is likely to form part of the Sydney Coastal River-flat Forest, an endangered ecological community under the *NSW Threatened Species Conservation Act*.

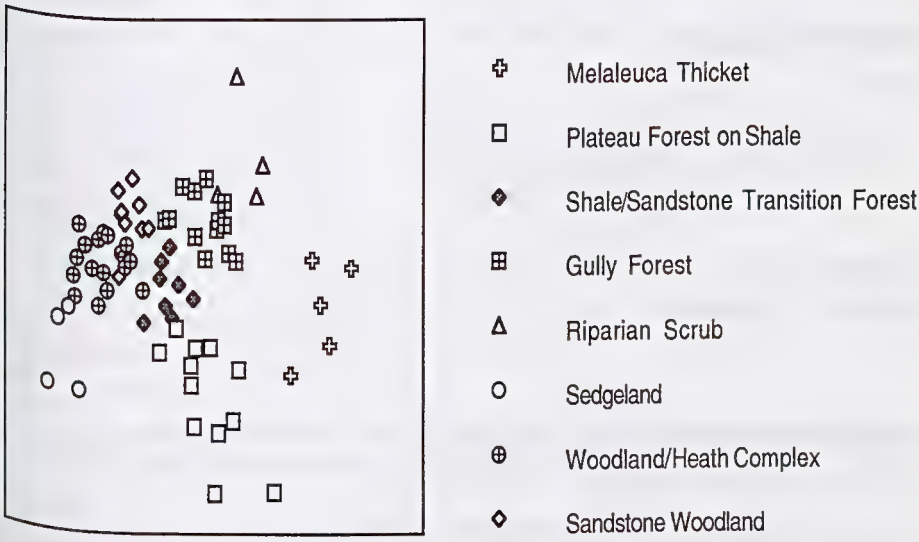

Fig. 2. Ordination analysis of seventy-three sites in Holsworthy Military Area using nonmetric multi-dimensional scaling. The symbols represent site classifications based on cluster and ordination analysis, field note interpretation and analysis of similarity (see text). Each vegetation community corresponds to descriptions in the text. Stress = 0.17.

Table 3. Sites surveyed based on major vegetation units using parent material, topography and structure.

Vegetation Type	Parent Material	Area (ha)	% Total Area	No. Species	No. Sites	Site Names Range: No.
Melaleuca	Alluvium	41+	0.2+	102	5	BR:1 B: 11, 17 C: 1, 4
Riparian	Sandstone/ Alluvium			115	4	B: 6 E: 13 G: 2, 5
Plateau Forest	Shale	1706#	9.5#	177	12	BR: 2 B: 1, 7, 9, 10, 12, 13, 15, 16, 18 C: 3 G: 4
Transition Forest	Shale/Sandstone		113	8	BR: 3	B: 2, 4 E: 6 H: 1, 5, 6, 7
Gully Forest	Sandstone	6917	38.7	213	13	B: 5 C: 5, 7 D: 1, 2, 7, 12, 14 E: 12 F: 5 G: 1, 3 H: 2
Woodland	Sandstone	9164	51.3	136	9	D: 3, 5 E: 1, 2, 5, 7, 8, 10 H: 4
Woodland/Heath Complex	Sandstone		0	165	18	B: 3, 8, 14 C: 2, 6 D: 4, 6, 8, 9, 10, 13 E: 3, 15 F: 1, 2, 3, 4 H: 3
Sedgeland	Sandstone	48	0.3	76	3	D: 11 E: 4, 9, 11

The area represented by each vegetation type and the % of the total area surveyed are based on calculation from the map interpretation. The sites are identified by the range (B-H) and numbered consecutively as they were surveyed. BR = Brigade Training Area.

+: Area could only be estimated for Melaleuca Thickets. Other riparian vegetation was too narrow to be mapped from aerial photoes.

#: This area is combined for both types of Plateau Forest that could not be distinguished from aerial photographs.

Table 4. Exotic species recorded at Holsworthy Military Area listed by family.

#: species classified as noxious either in the Liverpool or Campbelltown Council areas (Liverpool City Council 1998, Campbelltown City Council 1999). **: species considered by the authors to be particularly important as weeds of native areas are also highlighted.

Species	Distribution
APOCYNACEAE	
Nerium oleander Oleander	Under powerlines 1km south of Gate 7, Dump 0.5 km west from gate 7A (off Heathcote Rd)
ASCLEPIDACEAE	
Gomphocarpus fruticosus Narrow-leaved Cotton Bush	Dump 0.5 km west from gate 7A (off Heathcote Rd)
ASPARAGACEAE	
Mysiphyllum asparagoides ** Bridal Creeper	17B
ASTERACEAE	
Ageratina adenophora ** Crofton Weed	Dump 0.5 km west from gate 7A (off Heathcote Rd)
Aster subulatus Bushy Starwort	17B
Bidens pilosa Cobbler's Pegs	Dump 0.5 km west from gate 7A (off Heathcote Rd)
Cirsium vulgare Spear Thistle	Dump 0.5 km west from gate 7A (off Heathcote Rd)
Conyza albida Tall Fleabane	1BR, 11B, 17B, 1G, 2G
Conyza canadensis Canadian Fleabane	17B
Dittrichia graveolens Stinkwort	Dump 0.5 km west from gate 7A (off Heathcote Rd)
Gnaphalium coarctatum Purple Cudweed	17B
Hypochaeris radicata Catsear	Dump 0.5 km west from gate 7A (off Heathcote Rd), 2BR, 12B, 17B, 13E, 1G, 3G
Pseudognaphalium luteoalbum Jersey Cudweed	17B
Senecio madagascariensis Fireweed	Dump 0.5 km west from gate 7A (off Heathcote Rd), 9B, 2G, 3G
Senecio tamoides	17B
Sigesbeckia orientalis Indian Weed	17B
Sonchus oleraceus Common Sowthistle	Dump 0.5 km west from gate 7A (off Heathcote Rd), 11B
CACTACEAE	
Opuntia stricta #** Prickly Pear	Near 'wells' off River Rd, west of site 6B
GENTIACEAE	
Centaurium erythraea Common Centaury	Dump 0.5 km west from gate 7A (off Heathcote Rd), 4B, 17B, 13E

Species	Distribution
LAURACEAE	
Cinnamomum camphora ** Camphor Laurel	Dump 0.5 km west from gate 7A (off Heathcote Rd), 1C
MALVACEAE	
Sida rhombifolia Paddy's Lucerne	Dump 0.5 km west from gate 7A (off Heathcote Rd)
OLEACEAE	
Ligustrum lucidum #** Large-leaved Privet	1BR
Ligustrum sinense #** Small-leaved Privet	Dump 0.5 km west from gate 7A (off Heathcote Rd), 17B
PLANTAGINACEAE	
Plantago lanceolata Plantain	Dump 0.5 km west from gate 7A (off Heathcote Rd), 9B, 2D, 7D
POACEAE	
Andropogon virginicus ** Whisky Grass	4E
Cortaderia selloana #** Pampas Grass	Under powerlines 1km south of Gate 7
Cynodon dactylon Common Couch	Dump 0.5 km west from gate 7A (off Heathcote Rd)
Paspalum dilatatum Paspalum	Dump 0.5 km west from gate 7A (off Heathcote Rd), 11B, 17B
Poa annua Winter Grass	Dump 0.5 km west from gate 7A (off Heathcote Rd)
Setaria gracilis Slender Pigeon Grass	Dump 0.5 km west from gate 7A (off Heathcote Rd), 17B
Stenotaphrum secundatum Buffalo Grass	Dump 0.5 km west from gate 7A (off Heathcote Rd)
POLYGONACEAE	
Acetosella vulgaris or *Rumex angiocarpa* Sheep Sorrel	11B
ROSACEAE	
Prunus sp. Plum	Dump 0.5 km west from gate 7A (off Heathcote Rd)
SALICACEAE	
Populus sp. Poplar	Under powerlines 1 km south of Gate 7
Salix sp.# Willow	Under powerlines 1 km south of Gate 7
SOLANACEAE	
Cestrum parqui #** Green Poisonberry	Dump 0.5 km west from gate 7A (off Heathcote Rd)
Solanum nigrum Blackberry Nightshade	Dump 0.5 km west from gate 7A (off Heathcote Rd), 17B
VERBENACEAE	
Verbena bonariensis Purple Top	Dump 0.5 km west from gate 7A (off Heathcote Rd)

Table 5. Melaleuca Thicket descriptors.

These species contributed up to 50% of the average similarity between sites within this community. Average abundance is the average Braun-Blanquet cover value. The cumulative % contribution of each species to the total average Bray-Curtis value is given.

Species	Average abundance	Cumulative %
Melaleuca linariifolia	4.00	15.63
Pteridium esculentum	2.40	26.87
Viola hederacea	2.60	37.31
Gahnia sieberiana	2.40	45.98

Table 6. Unique species which occur at 2, 3, 4 and more than 4 sites in a vegetation community.

Numbers in brackets indicate the number of sites in each vegetation community. Species which occur only in one vegetation community but which occur at more than one site are likely to be more typical components of the vegetation.

(No. sites)	2 times	3 times	4 times	> 4 times
Melaleuca (5)	*Adiantum aethiopicum* *Blechnum cartilagineum* *Baumea rubiginosa* *Eleocharis sphacelata*	*Eucalyptus botryoides/saligna* *Hydrocotyle laxiflora* *Isolepis cernua* *Acacia irrorata*		
Plateau Forest on Shale (12)	*Acacia penninervis* *Chorizema parviflorum* *Eucalyptus crebra* *Eucalyptus resinifera* *Goodenia paniculata* *Macrozamia spiralis* *Paspalidium distans*	*Comesperma sphaerocarpum* *Daviesia ulicifolia* *Lagenifera stipitata* *Opercularia diphylla* *Pultenaea villosa* *Vernonia cinerea*	*Danthonia longifolia* *Senecio hispidula*	*Eucalyptus fibrosa* *Eucalyptus globoidea* *Oxalis* sp.
Shale/ Sandstone Transition Forest (8)	*Dillwynia floribunda*			
Riparian Scrub (4)	*Leptospermum morrisonii* *Phebalium dentatum* *Todea barbata*			
Gully Forest (13)	*Gompholobium latifolium* *Leucopogon lanceolata* *Leucopogon amplexicaulis* *Persoonia laurina*	*Eriostemon scaber*	*Actinotus helianthi*	
Woodland/ Heath (18)	*Cryptandra ericoides* *Hibbertia sericea* *Schoenus moorei*	*Allocasuarina diminuta* *Leucopogon appressus*	*Baeckea brevifolia*	
Woodland (9)	*Eucalyptus sieberi*		*Schoenus turbinatus* *Epacris obtusifolia*	*Eucalyptus consideniana*
Sedgeland (4)	*Schoenus paludosa* *Symphionema paludosum*	*Sprengelia incarnata*		

Sites: 1BR, 11B, 17B, 1C, 4C.

Habitat: Waterlogged creek beds on deep alluvium.

Distribution: 41 ha and 2% of the study area. Melaleuca Thickets occur mostly in the north of the study area, where large deposits of fertile, recent river alluvium occur.

Trees: 20 m (average height) and 10% cover (average cover). *Melaleuca linearifolia* and *Eucalyptus botryoides/saligna* intergrade.

Shrubs: 2 m and 10% cover. *Melaleuca linariifolia* and *Gahnia sieberiana*. Other species include *Callistemon citrinus, Ligustrum lucidum, Leptospermum juniperinum, Backhousia myrtifolia* and *Phyllanthus gastroemii*.

Groundcover: 0.5 m and 50% cover. *Isolepis cernua*, with *Entolasia marginata, Pteridium esculentum, Viola hederacea, Austrostipa ramosissima, Hydrocotyle laxiflora* and *Themeda australis*. Other species include *Calochlaena dubia, Eleocharis sphacelata* and *Adiantum aethiopicum*.

Vegetation Community: Plateau Forest on Shale.

Plateau Forest on Shale sites were distinguished from a Shale/Sandstone Transition Forest where sandstone influences were more obvious (ANOSIM: Global R = 0.392, p = 0.001). Plateau Forest on Shale was very variable with an average similarity between sites of 31% but in general was dominated by *Themeda australis* with an overstorey of *Eucalyptus crebra, Eucalyptus fibrosa, Eucalyptus punctata* and *Eucalyptus globoidea*. These shale communities are the most diverse in the study area with 177 species recorded. Seven species contributed up to 50% of the similarity between sites, most species occurring in the groundcover (Table 7). Forty-eight species (representing 27% of the shale flora) were unique to this vegetation community, indicating the importance of Plateau Forests on Shale, like Melaleuca Thickets, to the plant biodiversity of the area. Nineteen occurred in more than one quadrat (Table 6). These forests are box-ironbark Cumberland Plain woodlands, an endangered ecological community classified under the *NSW Threatened Species Conservation Act 1995*.

Sites: 2BR, 1B, 7B, 9B, 10B, 12B, 13B, 15B, 16B, 18B, 3C, 4G.

Habitat: Flat plateau tops on shale or Tertiary alluvium.

Distribution: 1706 ha (9.5% of the study area). This estimate includes both plateau forest types; Plateau Forest on Shale and Shale/Sandstone Transition Forest. It is found mostly in B range in the north-western corner of the study area. Some smaller patches occur in the north-east where shale lenses are overlying sandstone.

Trees: 15 m and 30% cover. *Eucalytpus fibrosa* and *Eucalytpus punctata*, with *Eucalytpus globoidea* and *Eucalytpus crebra*. Other species included *Eucalytpus tereticornis, Eucalytpus eugenioides, Eucalytpus moluccana, Eucalytpus longifolia* and occasionally *Angophora bakeri*.

Table 7. Plateau Forest on Shale descriptors.

These species contributed up to 50% of the average similarity between sites within this community. Average abundance is the average Braun-Blanquet cover value. The cumulative percentage contribution of each species to the total average Bray-Curtis value is given.

Species	Average abundance	Cumulative %
Themeda australis	4.17	17.45
Aristida vagans	2.42	25.71
Dianella revoluta	2.42	32.58
Entolasia stricta	2.17	37.65
Goodenia hederacea	1.83	41.75
Lomandra multiflora	1.58	45.32
Lissanthe strigosa	1.5	48.30

Table 8. Shale/Sandstone Transition Forest descriptors.

These species contributed up to 50% of the average similarity between sites within this community. Average abundance is the average Braun-Blanquet cover value. The cumulative % contribution of each species to the total average Bray-Curtis value is given.

Species	Average abundance	Cumulative%
Entolasia stricta	3.88	10.25
Cyathochaeta diandra	2.87	16.59
Acacia linifolia	2.63	22.66
Banksia spinulosa	2.88	28.58
Lomandra obliqua	2.63	34.35
Leptospermum trinervium	2.13	39.25
Phyllanthus hirtellus	2.25	43.95
Ptilothrix deusta	2.38	47.53

Table 9. Gully Forest descriptors.

These species contributed up to 50% of the average similarity between sites within this community. Average abundance is the average Braun-Blanquet cover value. The cumulative % contribution of each species to the total average Bray-Curtis value is given.

Species	Average abundance	Cumulative %
Entolasia stricta	3.15	7.25
Xanthosia pilosa	2.38	12.33
Lomandra gracilis	2.31	16.71
Angophora costata	2.54	21.07
Pteridium esculentum	2.08	25.21
Acacia linifolia	2.08	28.73
Banksia spinulosa	2.00	32.12
Lepidosperma laterale	1.92	35.43
Lomatia silaifolia	1.54	38.32
Lomandra obliqua	1.85	41.20
Platysace linearifolia	2.08	44.02
Corymbia gummifera	1.77	46.66
Banksia serrata	1.69	49.11

Shrubs: Little shrub layer is present though patches of *Bursaria spinosa, Dillwynia parviflora, Pultenaea villosa, Daviesia ulicifolia* and *Lissanthe strigosa* occur throughout the area.

Groundcover: 0.2 m and 40% cover. *Themeda australis* with *Entolasia stricta, Glycine tabacina* and *Dianella revoluta*. Other species include *Aristida vagans, Lomandra filiformis* ssp. *coriacea, Goodenia hederacea, Lomandra multiflora, Hardenbergia violacea, Ptilothrix deusta* and *Brunoniella australis.*

Vegetation Community: Shale/Sandstone Transition Forest.

Shale/Sandstone Transition Forest had a higher average similarity (40%) than the Plateau Forest on Shale, indicating that sites were reasonably similar in this community. These forests were either on shale or sandstone but were clearly influenced by both geology types. All sites occurred on more isolated plateaus with shale cappings or on the southern edge of the main shale plateau in the north. Although the geology of the area appears equivocal, it is possible that this area is influenced by the Mittagong Formation, a geology producing intergrading shale and sandstone based soils. Unlike the Plateau Forest on Shale, these forests had a more significant shrub layer with *Themeda australis* less dominant in the ground layers. Together with five species in the groundcover, these made up to 50% of the similarity between sites (Table 8). Only five species (4% of the flora) were unique to Shale/Sandstone Transition Forest of which only one occurred in more than one quadrat (Table 6), supporting its status as transition between sandstone and shale communities. These forests are likely to be Shale/Sandstone Transition Forest, an endangered ecological community classified under the *NSW Threatened Species Conservation Act 1995.*

Shale/Sandstone Transition Forest and Plateau Forest on Shale could not be distinguished easily using aerial photo interpretation as although differences in canopy trees could often be distinguished, canopy species occurred in small patches throughout the plateau and changed over smaller spatial scales than reasonable to map. Consequently, the map only shows the combined region as plateau forest. In general, however, the northern part of the plateau was largely Plateau Forest on Shale and the southern part, Shale/Sandstone Transition Forest.

This vegetation community differed from Gully Forest in having a significant groundcover of *Cyathochaeta diandra, Themeda australis* and *Ptilothrix deusta*. Site 4B is least similar to other sites as it is a heath area with no overstorey species.

Sites: 3BR, 2B, 4B, 6E, 1H, 5H, 6H, 7H.

Habitat: Flat plateau tops on shale or sandstone.

Distribution: 1706 ha (9.5% of the study area) includes both plateau forest types. Found mostly in the south of B range and in the south west of the study area.

Trees: 17 m and 25% cover. *Eucalyptus punctata, Angophora costata, Corymbia gummifera* and *Eucalyptus sparsifolia*. Other species include *Angophora bakeri, Angophora floribunda, Eucalyptus globoidea, Eucalyptus haemastoma/racemosa, Eucalyptus squamosa* and *Eucalyptus pilularis.*

Shrubs: 1 m and 20% cover. *Banksia spinulosa, Acacia linifolia, Leptospermum trinervium, Dillwynia parviflora* and *Isopogon anemonifolius*. Other species include *Hakea sericea, Hakea dactyloides, Acacia longifolia, Lissanthe strigosa* and *Grevillea mucronulata*.

Groundcover: 0.3 m and 50% cover. *Entolasia stricta, Cyathochaeta diandra, Lomandra obliqua, Themeda australis* and *Ptilothrix deusta*. A variety of other *Lomandra* species were also frequently encountered.

Vegetation Community: Gully Forest

Gully Forest on sandstone differed significantly from Shale/Sandstone Transition Forest (Global $R = 0.663$, $p < 0.001$). The main differences were in the replacement of a significant cover of grass with a more diverse shrub layer. Thirteen sites were grouped as Gully Forest occurring on the slopes falling away from the plateaus and into the gullies. This vegetation type is very common in the study area. Thirteen species contributed up to 50% of the average similarity (40%), mostly woody shrubs and canopy species (Table 9). Gully Forest included 34 species that were unique which represented 16% of the floral diversity. This community differed from the forests on the plateau and from Riparian Scrub in being dominated by *Angophora costata* with *Pteridium esculentum* and *Platysace linearifolia* in the understorey. Most sites in the west had a taller overstorey, with trees up to 30 m. Sites to the east and central parts of the area tended to have a smaller overstorey with trees from 8 to 20 m tall. Some sites to the west do not have a steep slope gradient. In these areas, Gully Forest occasionally grow to the ridge tops.

Sites: 5B, 5C, 7C, 1D, 2D, 7D, 12D, 14D, 12E, 5F, 1G, 3G, 2H.

Habitat: Slopes of sandstone gullies. Soils are well-drained, moist to dry, sandy loam in texture and either shallow or skeletal in depth.

Distribution: 6917 ha (38.7% of the study area). Most major gullies in the study area, but predominant in the southern part of the area, dominated by sandstone parent geology. Some Gully Forest appears on the top of ridges to the west.

Trees: 20 m and 25% cover. *Angophora costata* with *Eucalyptus piperita, Eucalyptus pilularis* and *Corymbia gummifera*. Other species co-occurring were *Banksia serrata, Eucalyptus punctata* and *Eucalytpus agglomerata*.

Shrubs: Tall shrubs were 3 m and 5% cover. *Ceratopetalum gummiferum* and *Banksia serrata* were dominant with *Allocasuarina littoralis* being common. Smaller shrubs were 1.5m and 20% cover. *Grevillea mucronulata, Banksia spinulosa, Lomatia silaifolia* and *Platysace linearifolia* were common. Other common species were *Xanthorrhoea arborea, Doryanthes excelsa* and *Acacia linifolia*.

Groundcover: 0.3 m and 10% cover. *Entolasia stricta, Xanthosia pilosa, Lomandra gracilis* and *Pteridium esculentum*. Other species co-occurring were *Lomandra multiflora, Lomandra obliqua, Lepidosperma laterale, Austrostipa pubescens, Gonocarpus teucrioides* and *Cyathocheata diandra*.

Vegetation Community: Riparian Scrub

Gully Forest merged with Riparian Scrub close to watercourses. Four sites were classified as Riparian Scrub which differed from the gully vegetation (ANOSIM: Global R = 0.660, p = 0.002). These sites were variable (average similarity only 30%). Part of this variation is due to the small sample size of this unit. Despite the small sample size, 115 species were identified in this area of which 16 species (14%) were unique to the community (Table 10). One site 5G occurred on much deeper alluvial deposits and was not as diverse, whilst 2G seemed most distinct from other riparian sites and gully vegetation. This was probably due to significant cover of species not occurring in other sites such as *Daviesia corymbosa, Restio dimorpha, Lomandra fluviatilis, Pseudanthus pimelioides, Grevillea oleoides* and *Monotoca scoparia.*

Sites: 6B, 13E, 2G, 5G.

Habitat: Along creek beds with alluvium on sandstone.

Distribution: Occurs on many of the creeks in the southern part of the study area at the bottom of deeper gorges with more frequent water. Also along the Georges River to the south of the study area.

Trees: These sites often have many of the tree species occurring in Gully Forest hanging over the creeks. These species add to the coverage of the community, but are not actually growing in the same substrate.

Shrubs: 4 m and 30% cover. *Tristaniopsis laurina, Lomatia myricoides, Ceratopetalum apetalum, Ceratopetalum gummiferum, Acacia obtusifolia* and *Allocasuarina littoralis* are common species. *Leptospermum polygalifolium, Daviesia corymbosa, Smilax glyciphylla* and *Cassytha pubescens* are frequently encountered.

Groundcover: 0.8 m and 10% cover. *Schoenus melanostachys, Entolasia stricta, Sticherus flabellatus, Xanthosia tridentata, Pteridium esculentum, Gleichenia dicarpa* and *Todea barbara.*

Vegetation Community: Sedgeland

Four sites in the south east were distinguished as Sedgeland with few overstorey shrubs and high similarity between sites (43%). These sites were poorly drained and occurred as small patches throughout the sandstone areas, although only four were sampled in this study. There were 76 species identified with 11 species (14%) unique to these sites of which four species occurred in more than one quadrat (Table 6). Five species contributed up to 50% of the average similarity between sites (Table 11).

Sites: 4E, 9E, 11E, 11D.

Habitat: Seepage slopes with underlying sandstone, usually above drainage lines. Soils are shallow, damp sandy loams with organics.

Distribution: 48 ha (0.3% of study area). The swamps largely occur to the south of the study area and are influenced by the sandstone geology. All sites recorded occurred in E or D range, where large sandstone outcrops and shelves are present. Other Sedgelands were present in C and B range.

Table 10. Riparian Scrub descriptors.

These species contributed up to 50% of the average similarity between sites within this community. Average abundance is the average Braun-Blanquet cover value. The cumulative % contribution of each species to the total average Bray-Curtis value is given.

Species	Average abundance	Cumulative %
Tristaniopsis laurina	3.00	10.14
Lomatia myricoides	2.50	19.41
Entolasia stricta	2.00	26.27
Ceratopetalum apetalum	2.25	32.18
Ceratopetalum gummiferum	2.25	37.34
Smilax glyciphylla	2.00	42.41
Xanthosia tridentata	1.25	47.04

Table 11. Sedgeland descriptors.

These species contributed up to 50% of the average similarity between sites within this community. Average abundance is the average Braun-Blanquet cover value. The cumulative % contribution of each species to the total average Bray-Curtis value is given.

Species	Average abundance	Cumulative %
Leptocarpus tenax	5.00	12.02
Schoenus brevifolius	4.25	21.89
Baeckea imbricata	4.00	31.27
Ptilothrix deusta	3.50	39.74
Stylidium graminifolium	3.25	46.69

Table 12. Woodland/Heath Complex descriptors.

These species contributed up to 50% of the average similarity between sites within this community. Average abundance is the average Braun-Blanquet cover value. The cumulative % contribution of each species to the total average Bray-Curtis value is given.

Species	Average abundance	Cumulative %
Cyathochaeta diandra	3.61	7.08
Actinotus minor	3.28	12.77
Angophora hispida	3.17	18.45
Petrophile sessilis	2.89	23.70
Ptilothrix deusta	3.17	28.87
Leptospermum trinervium	2.56	33.38
Lepyrodia scariosa	2.67	37.39
Hakea dactyloides	2.11	40.78
Banksia oblongifolia	2.33	44.04
Pultenaea elliptica	2.11	47.00
Lomandra glauca	2.17	49.80

Trees: No trees are present at the swampy sites.

Shrubs: Two sites had a shrub substratum of 0.7 m and 10–30% cover. *Banksia oblongifolia, Hakea teretifolia* and *Symphionema paludosa* dominated.

Groundcover: 0.5 m and 90% cover. *Leptocarpus tenax, Schoenus brevifolius* and *Baeckea imbricata* are common. Other species included *Stylidium graminifolium, Lepyrodia scariosa, Dampiera stricta, Epacris obtusifolia, Selaginella uliginosa, Drosera spathulata, Dillwynia floribunda* var. *floribunda* and *Sprengelia incarnata.*

Vegetation Community: Woodland/Heath Complex

Woodland/Heath Complex sites with poor drainage, but with more significant tall shrub and canopy layers, were distinguished from Sedgelands (ANOSIM: Global $R = 0.854$, $p < 0.001$). These sites had an average similarity of 45% but varied in the presence and cover of canopy species. Consequently, whilst aerial photo interpretation distinguished heath, this graded into woodland and could not be readily distinguished on species composition in the multivariate analysis. Overall, 165 species were identified in this community. Eleven species contributed up to 50% of the similarity (Table 12) and 14 species (8%) were unique to this vegetation type of which six were found in more than one quadrat (Table 6).

This woodland type differs markedly from the Sandstone Woodland in that the tree overstorey is not as tall and covers much less area within the site. Unlike the Sandstone Woodland, these sites have *Angophora hispida* in the shrub layer, indicating a wetter soil substrate, with laterite being the predominant parent material. Some of the sites in this community have no tree substratum.

Sites: 3B, 8B, 14B, 2C, 6C, 4D, 6D, 8D, 9D, 10D, 13D, 3E, 15E, 1F, 2F, 3F, 4F, 3H.

Habitat: Ridge tops with little to no slope. Soils are well drained to damp, shallow sandy loams. Sandstone or laterite over sandstone. Often situated in shallow depressions at the heads of creek tributaries.

Distribution: This vegetation type is found mainly in the central and north-eastern part of the study area with most sites occurring in F and D ranges. There are outlier sites that occur to the west in B and H ranges. In terms of the API map units, it includes all heath sites (146 ha, 0.8% of the study area) and some open moister parts of the woodland complex.

Trees: 6 m and 15% cover. *Eucalyptus haemastoma/racemosa, Eucalyptus squamosa* and *Corymbia gummifera* although a number of sites have no overstorey (6D, 13D, 3E, 15E, 2F).

Shrubs: 1.5 m and 30% cover. *Angophora hispida* with *Leptospermum trinervium, Banksia oblongifolia, Hakea dactyloides* and *Lambertia formosa.* Other common species were *Kunzea capitata, Isopogon anemonifolius, Banksia spinulosa* and *Phyllota phylicoides.*

Groundcover: 0.4 m and 68% cover. *Cyathochaeta diandra, Actinotus minor* with *Ptilothrix deusta* and *Lepyrodia scariosa.* Other common species were *Lomandra glauca, Lomandra obliqua, Lindsaea linearis* and *Entolasia stricta.*

Vegetation Community: Sandstone Woodland

In the southern part of the area a drier woodland was distinguished from the moister widespread Woodland/Heath Complex (ANOSIM: Global R = 0.646, $p < 0.001$). Nine sites formed the Sandstone Woodland community with an average similarity of 45%. There were 136 species identified of which 14 species contributed up to 50% of the similarity (Table 13). Seven species were unique to this community, three of these were common eucalypt species and three species occurred in more than one quadrat (Table 6).

Most sites to the south of D range had taller overstorey trees, with some specimens up to 25 m. This type of woodland differs from the others in that the vegetation occurs on dry ridges, all with sandstone parent material. These sites tend to be confined to E range and southern areas in D range with *Corymbia gummifera* as the dominant eucalypt. Sites had an average Bray-Curtis similarity value of 45%.

Sites: 3D, 5D, 1E, 2E, 5E, 7E, 8E, 10E, 4H.

Habitat: Dry sandstone ridges in the south of the study area. Soils are well-drained and usually dry, sandy loam and shallow. Sandstone outcrops are common.

Distribution: 9018 ha (50.5% of the study area. NB: this figure is for the whole of the woodland complex). The dry open woodland occurs along most of the sandstone ridges in the southern part of the range, with some ridges extending into the central and western areas.

Trees: 10 m and 30% cover. *Corymbia gummifera, Eucalyptus oblonga, Eucalyptus consideniana* with *Eucalyptus haemastoma/racemosa*. Other common species were *Banksia serrata, Banksia ericifolia, Eucalyptus sieberi*, and *Eucalyptus multicaulis*.

Shrubs: 2 m and 40% cover. *Leptospermum trinervium* with *Banksia serrata, Platysace linearifolia, Platysace ericoides* and *Isopogon anemonifolius*. Other common species were *Eriostemon australasius, Lambertia formosa* and *Petrophile sessilis*.

Groundcover: 0.2 m and 30% cover. *Cyathochaeta diandra* with *Lomandra glauca*. Other common species included *Xanthorrhoea media, Caustis flexuosa, Schoenus ericetorum* and *Lepyrodia scariosa*.

Exotic species

Thirty-eight exotic species were found in the Military Area (Table 4). Observations of weeds in areas other than the surveyed sites were noted and are included in this list. Six species are considered noxious in the area and are an immediate management issue. These are *Cestrum parqui, Cortaderia selloana, Opuntia stricta , Ligustrum lucidum, Ligustrum sinense* and *Salix* sp. Noxious classification is largely based on threats to agriculture and differs between local government areas. Seven exotic species, are considered to pose serious threats to native plant communities and are listed (Table 4). Most species occurred in the shale areas, emphasising the importance of management for these areas. Most exotic species were found at the dump in the northern part of the area and at site 17B, which is close to urban development. Few exotic species were found away from roadsides and highly disturbed areas.

Table 13. Sandstone Woodland descriptors.

These species contributed up to 50% of the average similarity between sites within this community. Average abundance is the average Braun-Blanquet cover value. The cumulative % contribution of each species to the total average Bray-Curtis value is given.

Species	Average Abundance	Cumulative %
Corymbia gummifera	3.11	5.55
Leptospermum trinervium	3.22	10.41
Cyathochaeta diandra	2.89	14.48
Lomandra glauca	3.11	18.32
Isopogon anemonifolius	2.33	21.75
Xanthorrhoea media	2.33	25.13
Platysace ericifolia	2.44	28.46
Eriostemon australasius	2.33	31.68
Caustis flexuosa	2.33	34.78
Dampiera stricta	2.11	37.70
Lambertia formosa	2.00	40.53
Platysace linearifolia	2.44	43.27
Cassytha pubescens	1.78	45.98
Bossiaea heterophylla	2.00	49.37

Table 14. Species of conservation significance found in the Holsworthy Military Area.

(a) Benson and McDougall (1991), (b) Benson and McDougall (1995), (c) Benson and McDougall (1996), (d) Benson and McDougall (1998), (e) Briggs and Leigh (1995), nl = not listed.

Species	Status	ROTAP Listing At 1995 (e)	Sites
Dilleniaceae			
Hibbertia nitida (b)	Uncommon in Sydney	2RC-	5D,7D
Fabaceae			
Chorizema parviflorum (c)	Vulnerable in western Sydney	nl	12B, 15B
Pultenaea hispidula (c)	Uncommon in Sydney	nl	1D
Zornia dyctiocarpa (b)	Vulnerable in western Sydney	nl	3C
Epacridaceae			
Leucopogon exolasius	V(TSCA), V(ESPA)	2VC-	5F, 5H
Myrtaceae			
Darwinia diminuta (d)	Rare local endemic	nl	4D, 6D, 8D, 9D, 10D, 11D, 13D
Eucalyptus baueriana (a)	Uncommon in western Sydney	nl	Williams Creek
Melaleuca deanei	V(TSCA2000), V(ESPA 1999)	3RC-	8B, 8D, 1E, 1H, 3H
Proteaceae			
Grevillea longifolia (a)	Rare in Sydney	2RC-	11B, 7C, 12E

Rare or threatened species

Ten rare or threatened species were found at the survey sites (Table 14). According to Briggs and Leigh (1995), three of these species are classified as rare (R) and have very restricted distributions in Australia with a maximum geographic range of less than 100 km (2) and one species is considered vulnerable (V). A further four are considered of conservation importance because they are uncommon. One has been listed since Briggs and Leigh (1995).

Discussion

Vegetation communities

Holsworthy Military Area is a species rich, relatively undisturbed example of Sydney vegetation, encompassing riverine communities (Riparian Scrub and Melaleuca Thickets), shale communities (Plateau Forest on Shale and Shale/Sandstone Transition Forest) and Hawkesbury Sandstone communities (Gully Forest, Sandstone Woodland, Woodland/Heath Complex and Sedgelands). All communities were significantly different when analysed on the basis of species composition and abundance.

Although not surveyed in this study, there are also considerable areas of Tertiary alluvium with *Melaleuca decora* and ironbark forests (Benson & Howell 1990a) to the north of the Holsworthy Military Area. These have been interpreted as Castlereagh Scribbly Gum Woodland (map unit 14a) (Benson 1992, James 1997) with some areas of Grey-box Ironbark Forest (map unit 10d) (James 1997), however this area requires ground surveys and analysis to classify correctly.

It is assumed that the plateau forests are formed on shale, however, Tertiary alluvium does occur in the area and due to the weathered nature of the rocks with few outcrops, the determination of soil type remains to be confirmed (I. Paterson pers. comm). It is feasible that some of the plateau forests in the north of the study area are on the Mittagong formation, intergrading sandstone and shale which lie between the Wianamatta shale beds and the underlying Hawkesbury Sandstone. This is consistent with the composition of the plant communities as transitional. It is also possible for alluvium to be present in small patches. However, geology maps do not appear accurate in this area (Sherwin & Holmes 1986, Jones & Clark 1991) and no new geological surveys have been completed. Confirmation of the soils therefore awaits further research.

It is appropriate to identify the characteristic species using an analysis that distinguishes the common important species independent of the knowledge of the observer. Vegetation classifications often rely on the extensive knowledge of the observer who determines the relative abundances of particular species while visiting sites. Knowledge of other sites is essential for reference. The classification is prone to bias if particular plant species are observed more readily by individuals and because variability in the system has not been quantified. It would be useful to characterise communities more precisely, providing 'less skilled managers' with a method of

determining the similarity of the sites they are observing, with established criteria. We used SIMPER to characterise the communities in the study area. This method has a number of advantages. Firstly, it provides a way of measuring variation in abundance of species, particularly canopy species, by identifying the average abundance of important taxa. Secondly, it uses the majority of species to do this, rather than only those large species obvious to an observer. Only rare species that had low percentage cover at one or two sites were removed for this analysis because of the limitations of the program. This ensures that features of the understorey and groundcover are used to describe communities, these strata, after all, are where the majority of plant diversity lies. By setting these species and abundance measures, these sites can be better compared to other sites within the Sydney area and the classification of particular vegetation communities (defined in this way) is not prone to subjective interpretation by others. Furthermore, this process will identify more clearly disturbed sites, as these areas often have reduced understorey diversity of native species.

An alternative way of describing vegetation units was used by Biosis (1997) which listed the frequency of species occurrence in sites. This method does not use high cover abundance as a criterion in choosing typical species. Instead, species which are widespread are included. The main disadvantage is that obvious species that contribute to the biomass of sites but which are aggregated and patchy, but nevertheless typical, are less likely to be included.

This point is kept in mind in determining the relationship of vegetation communities identified here (Table 3) with those of Benson (1992), Keith (1994) and Biosis Research and PPK (1997). In general, most communities encountered are similar to other vegetation communities described. Melaleuca Thickets equate closely to River-flat forest (Biosis Research 1997), and Riparian Scrub equates to descriptions under the same name in both Keith (1994) and Biosis Research and PPK (1997). However, for Riparian Scrub the variablity in species dominating sites is evident, corroborating the high variability found between sites in this study. Clearly this community is spatially variable or is made up of a number of communities. Comparison with other datasets may improve our understanding of these sites.

The forests on the plateau appear to be an area of contention. Benson (1992) describes the area as Grey-box Woodland (map unit 10C) and Biosis Research (1997) defines the area as Grey-box Ironbark Woodland (map unit 10D). Our classification is in agreement with Biosis Research and PPK like that analysis, distinguishes a transition forest where it grades into sandstone. This area appears similar to the Shale Forest described in Keith (1994), however, Holsworthy forest had lower cover with *Cyathochaeta diandra* and *Entolasia stricta* being dominant groundcover species. The Gully Forest at Holsworthy are more similar to the Eastern Gully Forests described by Keith (1994) and equate with Sydney Sandstone Gully Forest described in Biosis Research (1997) and Benson (1992; map unit 10agiii). The sandstone communities follow Keith's descriptions for Sedgeland and Sandstone Woodland. However, the Woodland/Heath Complex appears to be a combination of Ironstone Heath and Heath Woodland in the O'Hares Creek area.

Unique species in each vegetation community are the result of two factors. A number of species are likely to be specific to particular communities and therefore of importance for the conservation of that community. However, these cannot be separated from a suite of rare species that may occur in more than one habitat but which are too rare to be encountered in this study. This is particularly true of those species that only occur at one site in the study. Species occurring at more than two sites within a vegetation community are more likely to be particular to that community (Table 6).

Few orchid species were identified during the study, due to the timing of the survey over a very dry summer. Only one species, *Thelymitra* sp. occurred in Shale/Sandstone Transition Forest. This study found only four species, however Biosis Research (1997) sampled at a wetter time and identified 21 species of orchid. Further work in the area has identified many other orchids including a number of new populations of the endangered *Pterostylis saxicola* (S. Hill unpub. data).

The conservation significance of Holsworthy Military Area

The Military Area has high conservation value for a number of reasons. Firstly it contains a large remnant of Cumberland Plain Woodlands, classified here as Plateau Forests on Shale. This community is listed under the *NSW Threatened Species Conservation Act 1995* (TSCA) due to its ecological significance. With only 6% of original woodland left in the Sydney Region (Benson & Howell 1990b), the Holsworthy remnant represents an important part of its survival. The distinction/similarity between these woodlands and other woodlands across the Cumberland Plain was not part of this study, but the classification of this community relative to other sites has shown that Holsworthy probably contains both 10C and 10D vegetation map units (Benson 1992, French et al. 2000). However, Holsworthy was distinguishable from other sites around Sydney in having few exotic species.

Secondly the closeness of these shale communities on the Cumberland Plains to the sandstone communities of the Woronora Plateau suggests that Shale/Sandstone Transition Forests could occur which are also listed under the TSCA. Again the Transition Forests identified in this study are likely to fall into such a classification but more work is required to determine the relationship of the vegetation communities described in this study to the described communities in the legislation. There are many similarities with the description of Shale/Sandstone Transition Forest listed within NPWS (2000) which sampled all Cumberland Plain vegetation except the area within the Holsworthy Military Area.

Thirdly, past landuse of Holsworthy, has resulted in few areas of human disturbance. Holsworthy has been restricted to Military personnel since 1912 (Axis Environmental & Australian Museum Business Services 1995b), ensuring that only the edges of the study area are disturbed by urban recreation, runoff and pollution. As a result, weed infestation is minimal. However, fire frequency is likely to have been high given the difficulty of controlling fires in the presence of unexploded ordinances which occur throughout the range and the use of this area as a firing range.

Four threatened species were identified in this study: *Hibbertia nitida* (2RC-), *Leucopogon exolasius* (2VC-), *Melaleuca deanei* (3RC-) and *Grevillea longifolia* (2RC-). The Environmental Impact Statement for the second airport (Biosis Research 1997) identified a further five species, one of which occurs on the Tertiary alluvium sites in the north (*Allocasuarina glareicola*), two on shale (*Persoonia nutans* and *Pterostylis saxicola*) and two on sandstone in the south (*Pultenaea aristata* and *Monotoca ledifolia*). The EIS also identified five other species as being of state significance: *Eucalyptus ligustrina, Hakea salicifolia, Persoonia mollis* subsp. *nectens, Tetratheca shiressii* and *Westringia longifolia*.

Holsworthy Military Area is an area of high conservation significance, not only in terms of biological diversity but also in terms of cultural heritage (Axis Environmental & Australian Museum Business Services 1995a). It represents an area of relatively undisturbed vegetation at the extreme west of the Woronora Plateau where rainfall is at its lowest and where it grades into the Cumberland Plain vegetation. This area complements the National Parks to the East and forms an important element in the conservation of the water quality of the Georges River.

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Appendix. Species list and sites where each species occurred.

Nomenclature follows Harden (1990–1993) and Jacobs and Everett (1996). Sh/SS Trans Forest = Shale/Sandstone Transition Forest.

Family Species	Melaleuca Thicket	Plateau Forest on Shale	Sh/SS Trans Forest	Gully Forest	Riparian Scrub	Sedgeland	Woodland/ Heath Complex	Sandstone Woodland
Acanthaceae								
Brunoniella australis		9B,12B,13B,15B, 16B,18B,3C	2B					
Adiantaceae								
Adiantum aethiopicum	1BR,11B							
Antheriaceae								
Caesia parviflora var. *parviflora*		10B					4D	
Caesia parviflora var. *vittata*		18B						
Laxmannia gracilis		10B,16B,18B,3BR					8B	8E
Thysanotus juncifolius						9E	8B,6C	3D
Tricoryne simplex		10B				4E	10D	
Apiaceae								
Actinotus helianthi				5F,3G,2H,			6C	
Actinotus minor				7C,2D,5C	2G	4E,11E	3B,8B,2C,6C, 4D,8D,9D,10D, 13D,3E,1F,2F, 3F,4F,3H	3D,5D,5E,7E 8E,4H
Hydrocotyle laxiflora	1BR,1C,4C							
Hydrocotyle peduncularis	11B							
Platysace ericoides		7B,10B,18B	4B,6E,1H, 5H,7H	5C,1D,7D,5F, 12D			3B,8B,2C,6C, 4D,8D,9D,10D, 13D,4F,3H	5D,1E,2E,5E, 7E,8E,10E,4H
Platysace lanceolata				14D				3D,5D,8E
Platysace linearifolia		7B,10B		5C,7C,1D,2D, 12E,5F,1G,2H	6B,13E	11D,11E	4D,6D,9D,10D, 13D,2F,3F,5H	3D,5D,12D,5E, 7E,8E,10E,4H
Trachymene incisa		2BR,10B	3BR					
Xanthosia pilosa		10B	5H	5B,5C,7C,1D, 2D,7D,12D,14D, 12E,5F,1G,3G, 2H	2G			5E,7E,3D,5D, 4H
Xanthosia tridentata			5H	5C,7C,2D,7D, 12D,12E,2H	6B,13E,2G,5G		9D,10D,13D,2F	5D,8E

Family Species	Melaleuca Thicket	Plateau Forest on Shale	Sh/SS Trans Forest	Gully Forest	Riparian Scrub	Sedgeland	Woodland/ Heath Complex	Sandstone Woodland
Araliaceae								
Astrotricha latifolia				1G				
Asclepiadaceae								
Marsdenia suaveolens	11B			2D,7D	6B			
Asparagaceae								
**Myrsiphyllum asparagoides*	17B							
Asteraceae								
**Aster subulatus*	17B							
Cassinia aureonitens				2H				
Cassinia denticulata				7D				
**Cirsium vulgare*	17B							
**Conyza albida*	1BR,11B,17B		3BR	1G	2G			
**Conyza canadensis*	17B							
Gnaphalium gymnocephalum				12D				
**Gnaphalium coarctatum*	17B							
Helichrysum collinum			3BR,1H				8B	
Helichrysum scorpioides		7B,10B,18B	4B,6E					
**Hypochaeris radicata*	17B	2BR,12B		1G,3G	13E			
Lagenifera stipitata		7B,15B,18B						
**Pseudognaphalium luteoalbum*	17B							
Senecio hispidulus		2BR,9B,12B,13B						
Senecio lautus				2H				
**Senecio madagascariensis*		9B		3G	2G			
**Senecio tamoides*	17B							
**Sigesbeckia orientalis*	17B							
**Sonchus oleraceus*	11B							
Sonchus sp.	1BR							
Vernonia cinerea		13B,16B,3C						
Baueraceae								
Bauera rubioides				7C	13E			
Bignoniaceae								
Pandorea pandorana		2BR		1G				

Family Species	Melaleuca Thicket	Plateau Forest on Shale	Sh/SS Trans Forest	Gully Forest	Riparian Scrub	Sedgeland	Woodland/ Heath Complex	Sandstone Woodland
Blandfordiaceae								
Blandfordia nobilis				2D		11D,4E,9E		5D
Blechnaceae								
Blechnum ambiguum					13E			
Blechnum cartilagineum	1C,4C							
Campanulaceae								
Wahlenbergia gracilis		10B	6E	3G,2H		9E		
Wahlenbergia stricta		10B	3BR,7H					
Cassythaceae								
Cassytha glabella					2G	11D	6C,4D,6D,9D 10D	
Cassytha pubescens	17B		3BR,2B,6E,1H, 5H,6H,7H	5C,12E,3G	6B,13E,5G	9E,11E	3B,8B,8D,13D, 3E,15E,1F,2F, 3F,4F,3H	3D,5D,1E,2E, 5E,7E,8E,10E, 4H
Casuarinaceae								
Allocasuarina diminuta							8B,14B,8D	
Allocasuarina distyla				7C				8E
Allocasuarina littoralis		4G	2B,4B	5B,5C,1D,1G, 3G	2G,5G		3B	
Allocasuarina torulosa	17B	16B						
Chenopodiaceae								
Einadia trigonos subsp. *trigonos*		17B						
Clusiaceae								
Hypericum gramineum		10B,13B,16B,18B	6E					
Colchicaceae								
Burchardia umbellata			6H				6D	
Commelinaceae								
Commelina cyanea	17B							
Cunoniaceae								
Ceratopetalum apetalum				7C	13E,2G,5G			
Ceratopetalum gummiferum				5C,2D,7D,12D, 14D,12E,1G,3G, 2H	6B,13E,5G			

Family Species	Melaleuca Thicket	Plateau Forest on Shale	Sh/SS Trans Forest	Gully Forest	Riparian Scrub	Sedgeland	Woodland/ Heath Complex	Sandstone Woodland
Cyperaceae								
Baumea juncea	1BR				2G			
Baumea rubiginosa	1C,4C							
Caustis flexuosa			6E,1H,5H	5C,1D,2D,7D, 12D,1G,3G,2H			2C,10D,4F	3D,5D,1E,2E, 5E,7E,8E,10E, 4H
Caustis pentandra				5C,12E	13E,2G		9D,10D	3D,8E
Chorizandra cymbaria	11B	10B			2G			
Cyathochaeta diandra		2BR,7B,10B,16B, 18B	3BR,2B,4B,1H, 5H,6H,7H	5C,12D,3G			3B,8B,14B,2C, 6C,4D,6D,8D, 9D,10D,13D,3E, 15E,1F,2F,3F,4F, 3H	3D,5D,1E,5E, 7E,8E,10E,4H
Eleocharis sphacelata	1BR,1C							
Gahnia sieberiana	1BR,11B,1C,4C			7C,12E	13E			7E,10E
Isolepis cernua	1BR,1C,4C							
Lepidosperma concavum			5H	3G				
Lepidosperma filiforme				5C			4D,9D	1E,7E
Lepidosperma laterale		10B,12B,3C,4G	2B,4B,6H	5B,5C,7C,1D, 2D,12D,14D,12E, 5F,1G,2H	13E,2G,5G		3B,14B,2C,4D, 10D	3D,2E,10E
Lepidosperma gunnii		1B,7B,9B,13B, 15B,16B,18B	3BR,7H	5B				
Lepidosperma neesii						4E	2F	
Lepidosperma concavum		2BR						
Ptilothrix deusta		1B,7B,12B,15B, 16B,18B,3C	2B,4B,6E,5H, 6H,7H			11D,4E,9E,11E	14B,2C,6C,4D, 6D,8D,9D,10D, 13D,3E,15E,2F, 3F,3H	3B,5D,1E,7E, 10E
Schoenus brevifolius	4C	10B		7C		11D,4E,9E,11E	6D,13D,3E	
Schoenus ericetorum			3BR,1F,5H				2C,6C,4D,8D, 9D,4F	3D,5E,7E,8E, 10E,4H
Schoenus lepidosperma subsp. *pachylepsis*					6B		8D	
Schoenus melanostachys		10B		2D,2H	13E,2G,5G			
Schoenus moorei							14B,1F	
Schoenus paludosus						9E,11E		
Schoenus turbinatus								3D,5E,7E,10E

Family Species	Melaleuca Thicket	Plateau Forest on Shale	Sh/SS Trans Forest	Gully Forest	Riparian Scrub	Sedgeland	Woodland/ Heath Complex	Sandstone Woodland
Cyperaceae cont.								
Schoenus villosus						2C	14B,2F,3H	3D
Tricostularia pauciflora	11B	10B						7E
Dennstaedtiaceae								
Hypolepis muelleri	1C							
Pteridium esculentum	1BR,11B,17B,1C, 4C	2BR		5B,5C,7C,1D, 2D,7D,14D,12E, 5F,1G,3G,2H	6B,5G	4E		
Dicksoniaceae								
Calochlaena dubia	1BR,11B,4C			1D,7D,12E,1G	13E,5G			
Dilleniaceae								
Hibbertia acicularis				7C				
Hibbertia aspera	11B	10B,12B						
Hibbertia circumdans				5C				
Hibbertia diffusa		7B						
Hibbertia empetrifolia					6B			
Hibbertia linearis		2BR						8E
Hibbertia monogyna			5H	1D,12D			3D	
Hibbertia nitida				7D			5D	
Hibbertia riparia			1H	1D			3B,4D,8D,9D, 13D,4F,3H	3D,1E,2E,5E, 10E,4H
Hibbertia sericea							4D,8D	
Hibbertia serpyllifolia		12B	6H				8B,14B,10D,3E, 2F	5D
Doryanthaceae								
Doryanthes excelsa				5B,1D,2D,7D, 14D				5D
Droseraceae								
Drosera peltata		10B						
Drosera spatulata				7C,2D	13E	4E,9E	6D	
Elaeocarpaceae								
Elaeocarpus reticulatus				1G				

Family Species	Melaleuca Thicket	Plateau Forest on Shale	Sh/SS Trans Forest	Gully Forest	Riparian Scrub	Sedgeland	Woodland/ Heath Complex	Sandstone Woodland
Epacridaceae								
Brachyloma daphnoides		2BR	1H,7H				2C,4D,10D,1F, 4F	3D,5D,2E,10E, 4H
Epacris longiflora			3BR	7D,12E	13E			
Epacris microphylla				5C		4E,9E,11E	2C,4D,6D,9D, 10D,13D,3E,2F	5E,7E
Epacris obtusifolia						11D,4E,9E		
Epacris pulchella			2B,6E,6H	7C,2D	6B		4D	5D,1E,7E
Leucopogon amplexicaulis				2D,7D				
Leucopogon appressus							8B,2F,3H	
Leucopogon ericoides	1BR	2BR	3BR,6H	5C,7C,2D,7D			2C,15E	
Leucopogon esquamatus						11D,4E	8D	
Leucopogon exolasius			5H	5F				
Leucopogon juniperinus			7H				2F	2E
Leucopogon lanceolatus				14D,12E				
Leucopogon microphyllus						11D,11E	3B,8B,2C,6C, 4D,6D,8D,9D, 10D,13D,3E,1F, 2F,4F	3D,5D,1E,5E, 7E,8E,10E
Lissanthe strigosa		1B,7B,10B,12B, 15B,16B,18B,3C	2B,6E,1H,5H, 6H,7H	3G			6C,1F	5D,1E,7E,8E, 4H
Melichrus procumbens							4F	
Melichrus sp.								8E
Monotoca elliptica				5C			9D	
Monotoca scoparia		2BR,7B	3BR,2B,1H	5B,1D,2D,7D, 14D,3G	2G		4D,9D,3F	3D,5D,2E,5E, 7E,8E,10E,4H
Sprengelia incarnata						11D,4E,9E		
Styphelia sp.				7D				
Woollsia pungens				5C			9D	3D,5E,7E
Euphorbiaceae								
Amperea xiphoclada	11B			7D,14D				5D
Bertya pomaderroides				7C				
Beyeria lasiocarpa					2G			
Micrantheum ericoides			2B,4B	7C	6B		8B,14B,2C,6D, 15E,1F,2F,3F, 4F	

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Euphorbiaceae cont.								
Phyllanthus gasstroemii	17B							
Phyllanthus hirtellus		1B,7B,10B,16B, 18B	3BR,2B,6E,1H, 5H,6H,7H	5B,7C,1D,12D, 14D,5F,1G,3G, 2H	6B		2C,3F,4F,15E, 4H	5D,2E,8E
Poranthera ericifolia				5C,2D	6B		4H	
Poranthera microphylla	17B	12B						
Pseudanthus pimeleoides					2G			
Ricinocarpos pinifolius				5C,7D				5D
Fabaceae								
Acacia binervia	17B							
Acacia decurrens	1BR	12B						
Acacia falcata		3C						
Acacia floribunda	11B				5G			
Acacia hispidula			1H	2H				
Acacia implexa	17B							
Acacia irrorata subsp. *irrorata*		2BR,10B,18B						
Acacia linifolia			3BR,2B,4B,6E, 1H,5H,6H,7H	5C,1D,2D,12D, 14D,12E,5F,1G, 2H	13E		3B,2C,15E,1F, 2F	5D,7E,8E,10E
Acacia longifolia	1C,4C	2BR,9B	7H	12E	6B,13E			
Acacia longissima				7C				
Acacia mearnsii		9B						
Acacia myrtifolia		7B	2B,6E,1H,6H, 7H				2C,15E	5D,1E,5E,7E, 8E
Acacia obtusifolia				7C	2G,5G			
Acacia penninervis		12B,15B						
Acacia suaveolens		1B,7B	1H,7H	2D,7D,12D,14D 5F,2H		11D,11E	3B,2C,9D,13D, 15E,3F	3D,5E,7E,8E
Acacia terminalis		1B,4G	3BR,5H,6H,7H	5C,7C,2D,7D, 14D,12E,5F,1G, 3G,2H	6B,13E,5G	4E	2C,3E	
Acacia ulicifolia		1B,7B,16B,4G	2B,4B,6E,1H, 5H,6H,7H	5B,5C,7C,1D, 2D,7D,14D,1G, 3G,2H			3B,2C,1F,2F	1E,2E,5E,4H
Aotus ericiodes				7D,14D		11E		

Family Species	Melaleuca Thicket	Plateau Forest on Shale	Sh/SS Trans Forest	Gully Forest	Riparian Scrub	Sedgeland	Woodland/ Heath Complex	Sandstone Woodland
Fabaceae cont.								
Bossiaea ensata			7H				2C,8D,9D,10D	3D,1E,5E,7E, 10E
Bossiaea heterophylla		2BR	1H,5H	5C,7C,1D,2D, 7D,12D,14D,5F, 3G,2H	6B	11D,11E	14B,6C,3F,4F, 3H	3D,5D,1E,5E, 7E,8E,10E,4H
Bossiaea obcordata			7H					
Bossiaea prostrata		1B,12B,15B,16B, 18B,3C,4H	3BR					
Bossiaea stephensonii				5C				
Chorizema parviflorum		12B,15B						
Daviesia corymbosa					6B,2G			2E,10E
Daviesia ulicifolia		9B,13B,15B						
Dillwynia floribunda var. *floribunda*			3BR,7H			4E,9E	3H,3E,1F,2F,3F	
Dillwynia floribunda var. *teretifolia*							4F	4H
Dillwynia parviflora		1B,12B,4G	2B					
Dillwynia retorta			4B,1H,5H,6H, 7H	5C,7C,1D,2D, 12D,12E,5F,2H	6B		2C,9D	3D,5D,8E,10E
Dillwynia sericea			6E				3B,8B,6C,6D, 8D,15E	1E
Glycine clandestina	17B	1B,7B,9B,10B, 12B,15B,16B,18B, 4G	6E	5B,1G				
Glycine tabacina	4C	9B,13B,15B,16B, 3C						
Gompholobium glabratum		3BR,6H					8B,2C,4D,6D, 8D,9D,15E,4F	3D,5E,10E
Gompholobium grandiflorum			1H,5H	7C,5F,2H			2C,9D,10D,15E	3D,5D,2E,5E, 7E,10E,4H
Gompholobium latifolium				7D,14D				
Gompholobium minus		2BR,7B,10B,16B, 18B	3BR,2B,5H,6H	3G				4H
Gompholobium sp.*B*		4G						
Hardenbergia violacea		12B,13B,15B,16B, 18B,3C	6E,5H	7C,1D,2D,7D, 14D,5F,1G,3G	6B,13E			
Hovea linearis		2BR,7B,10B	3BR,2B,1H,7H	5B,1D,2D,12D, 2H			9D,10D,15E,4F	3D,5D,7E

Family Species	Melaleuca Thicket	Plateau Forest on Shale	Sh/SS Trans Forest	Gully Forest	Riparian Scrub	Sedgeland	Woodland/ Heath Complex	Sandstone Woodland
Fabaceae cont.								
Indigofera australis		13B						
Kennedia rubicunda	11B,4C			5B				
Mirbelia rubiifolia			2B			11D,9E	6D	1E
Mirbelia speciosa			1H,6H				15E	2E,5E,7E,10E
Phyllota phylicoides		2BR					8B,14B,2C,6C, 4D,6D,8D,9D, 10D,15E,4F	
Pultenaea daphnoides			6E	5C,2D,7D,14D				
Pultenaea elliptica			2B,4B,1H	5C,7C		11D	3B,8B,14B,2C, 6C,4D,6D,8D, 9D,10D,13D,3E, 15E,1F,2F	3D,5D,5E,7E, 8E,10E
Pultenaea flexilis				5B,1D,12E,1G	13E,2G			
Pultenaea hispidula				1D				
Pultenaea scabra var. *scabra*		10B		5D,7D				
Pultenaea stipularis				12D,12E				3D,5E
Pultenaea villosa		12B,15B,3C						
Viminaria juncea			6E			11D,9E		
Zornia dyctiocarpa		3C						
Gentianaceae								
**Centaurium erythraea*	17B		4B		13E			
Geraniaceae								
Geranium sp.			3BR					
Gleicheniaceae								
Gleichenia dicarpa	1BR,4C			7C	6B,13E	4E		
Gleichenia microphylla					2G			
Gleichenia rupestris				2D				
Sticherus flabellatus				7C	6B,13E,2G			
Goodeniaceae								
Dampiera purpurea	11B	10B	5H	5B,7C,1D,14D, 12E,1G,3G,2H				
Dampiera stricta			1H,5H	7C		4E,9E,11D,11E	3B,8B,14B,2C, 6C,4D,6D,9D, 10D,13D,3E,15E, 1F,3F,4F,3H	3D,1E,2E,5E, 7E,8E,10E,4H

Family Species	Melaleuca Thicket	Plateau Forest on Shale	Sh/SS Trans Forest	Gully Forest	Riparian Scrub	Sedgeland	Woodland/ Heath Complex	Sandstone Woodland
Goodeniaceae cont.								
Goodenia bellidifolia		12B	3BR,2B,4B,6H				3B,14B,6C,10D, 3H	1E
Goodenia dimorpha var. *angustifolia*						9E		
Goodenia hederacea	3BR	1B,7B,10B,12B, 15B,16B,18B,3C	6E	5B,3G				
Goodenia paniculata		2BR,10B						
Scaevola ramosissima			2B,7H	14D			15E,2F	3D,5D,8E
Haemodoraceae								
Haemodorum corymbosum	6B		5H			11D,4E,11E	2C,4D,13D,3E, 1F,3H	7E
Haloragaceae								
Gonocarpus micranthus	11B							
Gonocarpus tetragynus		7B,10B,12B,15B, 16B,18B	6E				2C,6D,3E	7E
Gonocarpus teucrioides	11B	1B,10B,12B,3C	4B,6E,6H	5B,7C,2D,7D, 14D,12E	6B,13E,2G		6C,9D,10D	
Iridaceae								
Patersonia glabrata			5H	5B,5C,7C,1D, 7D,2H			1F,3H	2E
Patersonia sericea		7B,10B,15B,16B, 18B,2C	3BR,2B,6H			11E	3B,8B,14B,6C, 4D,6D,8D,9D, 10D,13D,3E,4F	3D,1E,5E,7E, 10E
Juncaceae								
Juncus continuus	1BR,11B				2G			
Juncus planifolius					2G			
Juncus usitatus					2G			
Juncaginaceae								
Triglochin procerum					2G			
Lamiaceae								
Hemigenia purpurea							8B	
Plectranthrus graveolens	17B							

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Lauraceae								
**Cinnamomum camphora*	1C							
Lindsaeaceae								
Lindsaea linearis		7B,4G	4B		2G	11D,4E	3B,8B,2C,6C, 4D,6D,8D,9D, 10D,15E,1F,4F, 3H	5D,1E
Lindsaea microphylla				5C,1D,2D,7D, 12D,12E,2H	6B,13E			
Lobeliaceae								
Lobelia alata	4C							
Lobelia dentata		10B						
Pratia purpurascens	1BR,11B,1C	3C						
Loganiaceae								
Logania albiflora				7C	6B,13E			
Mitrasacme polymorpha		10B				11E	4F	7E,8E,10E
Lomandraceae								
Lomandra cylindrica		2BR,7B	5H,6H	5B,5C,12D,1G			1F	7E,8E,10E,4H
Lomandra filiformis subsp. *coriacea*		10B,15B,16B,18B, 4G	4B,6H	14D			2C,6C,9D,15E	5D
Lomandra filiformis subsp. *filiformis*		1B,7B,	2B,1H,5H	5C,1D,7D,12D, 14D,5F,2H			3B	3D
Lomandra fluviatilis		10B		7C	2G			
Lomandra glauca		7B,9B	3BR,2B,5H,6H	12D,5F			8B,14B,2C,6C, 4D,8D,9D,10D, 15E,1F,3F,4F, 3H	3D,5D,2E,5E, 7E,8E,10E,4H
Lomandra gracilis		4G	6E,5H,7H	5B,7C,1D,2D, 7D,12D,14D,12E 5F,1G,3G	6B,13E		8B,14B,4F	8E,4H
Lomandra longifolia	1BR,11B,17B,1C	2BR,10B,13B,16B	3BR,6B,6E	1D,2D,7D,14D, 12E,1G	13E,5G			
Lomandra multiflora		7B,9B,10B,12B, 15B,16B,18B,3C, 4G	4B,6E,1H,6H, 7H	5B,5C,7C,12D, 1G,3G,2H			2C,6C	8E,4H
Lomandra obliqua		2BR,1B,7B,10B, 16B,18B	3BR,2B,4B,6E, 1H,5H,6H,7H	5B,5C,7C,1D, 2D,7D,14D,5F, 1G,3G,2H		11E	3B,8B,2C,6C, 8D,9D,10D,15E, 1F,2F,3F,4F,3H	3D,1E,7E,8E, 10E

Family Species	Melaleuca Thicket	Plateau Forest on Shale	Sh/SS Trans Forest	Gully Forest	Riparian Scrub	Sedgeland	Woodland/ Heath Complex	Sandstone Woodland
Lycopodiaceae								
Lycopodium laterale						9E		
Myrsinaceae								
Rapanea variabilis				5B				
Myrtaceae								
Angophora bakeri		10B,12B,15B,16B, 3C	3BR,6H	5F				
Angophora costata		1B,7B,18B,4G	2B,6E,1H,5H	5B,1D,2D,7D, 12D,14D,12E,5F 1G,3G,2H	6B,13E,2G			5D,8E
Angophora floribunda		2BR						
Angophora hispida				7C		11D	3B,8B,14B,2C, 6C,4D,6D,8D, 9D,10D,13D,3E, 15E,1F,2F,3F,4F, 3H	
Austromyrtus tenuifolia					2G			
Backhousia myrtifolia	17B							
Baeckea brevifolia							8B,4D,6D,2F	
Baeckea diosmifolia						4E	13D,3E,3H	
Baeckea imbricata						11D,4E,9E,11E	6D,13D	
Baeckea linifolia				7C	5G			
Baeckea ramosissima							8B,2C,4D,8D, 2F,3H	5E
Callistemon citrinus	1BR,11B			7C,2G		11D	2F	
Callistemon linearis			2B,4B			4E	3B,13D	
Calytrix tetragona				7C	2G		9D,10D	
Darwinia diminuta						11D	4D,6D,9D,10D, 13D	
Darwinia fascicularis					2G	11E		
Eucalyptus agglomerata				2H				
Eucalyptus beyeriana		18B						
Eucalyptus botryoides/saligna	17B,1C,4C							
Eucalyptus consideniana								3D,1E,2E,5E, 4H
Eucalyptus crebra		9B,13B						

Family Species	Melaleuca Thicket	Plateau Forest on Shale	Sh/SS Trans Forest	Gully Forest	Riparian Scrub	Sedgeland	Woodland/ Heath Complex	Sandstone Woodland
Myrtaceae cont.								
Eucalyptus eugenioides		9B						
Eucalyptus fibrosa		9B,12B,13B,15B, 16B,3C						
Eucalyptus globoidea		12B,15B,16B,18B, 3C,4G						
Eucalyptus gummifera		1B,7B,16B,18B	2B,6E,1H,6H, 7H	5B,5C,7C,1D, 2D,7D,12D,12E, 5F,3G			2C,6C,4D,9D, 15E,1F,3F,4F	3D,5D,1E,2E, 5E,7E,8E,10E, 4H
Eucalyptus haemastoma/ racemosa intergrade		10B	4B,6E				2C,6C,4D,6D, 9D,10D,3E,15E, 3F,4F,5F	3D,5D,8E,10E
Eucalyptus longifolia		12B						
Eucalyptus moluccana		9B						
Eucalyptus multicaulis								5D
Eucalyptus oblonga		4G	3BR,5H				2C,6D,9D,4F	2E,5E,7E,10E, 4H
Eucalyptus pilularis			7H	1G,3G,2H	6B,5G			
Eucalyptus pilularis/ piperita intergrade				5B				
Eucalyptus piperita	1BR			5C,7C,2D,7D, 12D,14D,12E,1G, 2H	6B			8E
Eucalyptus punctata	11B	7B,10B,16B,18B, 4G	2B,1H,5H,6H, 7H	1G,2H			15E	
Eucalyptus resinifera		1B,18B						
Eucalyptus sclerophylla		2BR						
Eucalyptus sieberi								7E,10E
Eucalyptus sparsifolia		1B,7B	2B					
Eucalyptus squamosa			1H,6H,7H				8B,14B,4D,8D, 10D	3D
Eucalyptus tereticornis		9B,16B						
Kunzea ambigua		4G					8B,1F	8E
Kunzea capitata		7B	4B,6H				3B,8B,14B,2C, 6D,8D,9D,15E, 1F,2F,3F,4F	
Leptospermum arachnoides				7C		11D,11E	3B,2C,6C,4D, 6D,8D,9D,10D, 13D,2F,3F	

Family Species	Melaleuca Thicket	Plateau Forest on Shale	Sh/SS Trans Forest	Gully Forest	Riparian Scrub	Sedgeland	Woodland/ Heath Complex	Sandstone Woodland
Myrtaceae cont.								
Leptospermum continentale						4E	3E	
Leptospermum juniperinum	1BR,11B,4C				13E			
Leptospermum morrisonii					2G,5G			
Leptospermum parvifolium			2B				3B	
Leptospermum polygalifolium		2BR,10B		5C,7C,2D,12E, 1G	6B,13E,5G	11D		
Leptospermum squarrosum						9E		
Leptospermum trinervium		2BR,7B,10B,15B, 16B,18B	3BR,2B,4B,6E, 1H,5H,6H,7H	5C,7C,2D,7D, 12D,14D,1G,3G, 2H		11D	3B,8B,14B,2C, 6C,4D,6D,8D, 9D,10D,13D,3E, 15E,1F,2F,3F, 4F,3H	3D,5D,1E,2E, 5E,7E,8E,4H
Melaleuca deanei			1H				8B,8D,3H	1E
Melaleuca decora		12B						
Melaleuca linariifolia	1BR,11B,1C,4C	10B			5G			
Melaleuca nodosa		10B						
Melaleuca thymifolia		12B	4B					
Syncarpia glomulifera		16B		1G,3G				
Tristania neriifolia				7C	2G			
Tristaniopsis laurina	17B				13E,2G,5G			
Olacaceae								
Olax stricta							10D	
Oleaceae								
**Ligustrum lucidum*	1BR							
**Ligustrum sinense*	17B							
Notelaea longifolia		10B						
Orchidaceae								
Caleana major				5F				
Cryptostylis erecta				14D				
Dendrobium linguiforme				1D,7D,12D	6B			
Dipodium punctatum		9B		12D				
Liparis reflexa				7D	13E			
Thelymitra sp.			4B					

Family Species	Melaleuca Thicket	Plateau Forest on Shale	Sh/SS Trans Forest	Gully Forest	Riparian Scrub	Sedgeland	Woodland/ Heath Complex	Sandstone Woodland
Osmundaceae								
Todea barbara					6B,13E			
Oxalidaceae								
Oxalis perennans	17B							
Oxalis radicosa	4C							
Oxalis sp.		2BR,9B,13B,15B, 3C						
Phormiaceae								
Dianella caerulea var. *caerulea*	1C		4B	5B,5C,7C,1D, 7D,14D,12E,1G, 2H	6B	11B	9D	
Dianella caerulea var. *producta*								5D
Dianella longifolia		13B						
Dianella revoluta		1B,7B,9B,10B, 12B,15B,16B,18B, 3C,4G	3BR,2B,6E,1H, 5H,7H	5B,1D,5F,1G, 3G	6B		15E	
Thelionema caespitosum						4E	6D	
Pittosporaceae								
Billardiera scandens	11B	2BR,7B,10B,18B	6E,7H	5C,14D,5F,1G, 3G,2H	6B		9D,4F	5D,4H
Bursaria lasiophylla var. *atriplicina*				5B				
Bursaria spinosa		9B,10B,12B,3C		5B				
Hymenosporum flavum	17B							
Rhytidosporum procumbens			2B				1F	
Plantaginaceae								
**Plantago lanceolata*		9B		2D,7D				
Poaceae								
Amphipogon strictus						4E	14B,6D	
Andropogon virginicus						4E		
Anisopogon avenaceus			3BR	5C,7C,7D			14B,2C,6C,4D, 6D,8D,9D,10D, 15E,4F	5E,7E
Aristida ramosa var. ramosa(?)		2BR						
Aristida ramosa var. speciosa		4G						

Family Species	Melaleuca Thicket	Plateau Forest on Shale	Sh/SS Trans Forest	Gully Forest	Riparian Scrub	Sedgeland	Woodland/ Heath Complex	Sandstone Woodland
Poaceae cont.								
Aristida vagans		1B,7B,9B,10B, 12B,13B,15B,16B, 18B,3C,4G	3BR,6H,7H	1G,3G			15E	
Aristida warburgii		4G	4B,6E				8B	
Austrodanthonia longifolia		7B,12B,15B,18B						
Austrostipa pubescens		7B,10B	2B,4B,1H,5H	5B,7C,1G,3G			3B,6C,15E,1F, 3F,4F,4H	5D,1E,2E,10E
Austrostipa ramosissima	17B							
**Chianochloa pallida*		1B,12B		2D,7D				
Deyeuxia contracta		10B						
Deyeuxia quadriseta		10B	4B					
Dichelachne micrantha		2BR,7B,15B,18B		1G				
Digitaria parviflora				1G				
Echinopogon ovatus	4C	10B,12B						
Entolasia marginata	11B,4C							
Entolasia stricta	17B,1C,4C	1B,7B,10B,12B, 15B,16B,18B,3C, 4G	3BR,2B,4B,6E, 1H,5H,6H,7H	5B,5C,7C,1D, 2D,7D,12D,14D, 12E,5F,1G,3G 2H	6B,13E,2G,5G	4E	3B,8B,14B,2C, 6D,3E,15E,1F, 3F,4F	5D,1E,5E,8E, 4H
Eragrostis brownii		4G						
Eragrostis parviflora		10B						
Hemarthia uncinata var. *uncinata*		10B						
Imperata cylindrica	11B,17B,1C,4C	2BR,1B,10B,4G	6E					
Microlaena stipoides var. *stipoides*		1BR,11B,17B	3C	7C				
Oplismenus aemulus	17B							
Panicum simile		1B,9B,12B,18B, 3C,4G	7H	1G				
Paspalidium distans		9B,13B						
**Paspalum dilatatum*	11B,17B							
Plinthanthesis paradoxa			6E					
Poa labillardieri	1BR							
**Setaria gracilis*	17B							
Tetrarrhena juncea				2D				

Family Species	Melaleuca Thicket	Plateau Forest on Shale	Sh/SS Trans Forest	Gully Forest	Riparian Scrub	Sedgeland	Woodland/ Heath Complex	Sandstone Woodland
Poaceae cont.								
Tetrarrhena turfosa					6B			
Themeda australis	4C	2BR,1B,7B,9B, 10B,12B,13B,15B, 16B,18B,3C,4G	3BR,4B,6E,6H	7C			15E	
Polygalaceae								
Comesperma defoliatum			3BR,4B				14B	
Comesperma sphaerocarpum		12B,16B,18B						
Comesperma volubile				5B				
Polygonaceae								
**Acetosella vulgaris*	11B							
Persicaria praetermissa	1BR,1C							
Persicaria strigosa					2G			
Proteaceae								
Banksia ericifolia			6E	7C,12D	5G	11D,4E,9E,11E	2C,6D,8D,9D, 10D,13D,3E,2F	3D,5D,1E,5E, 7E,8E
Banksia integrifolia subsp. *integrifolia*		2BR						
Banksia marginata				7C,12D,12E	6B,5G		4D,6D,8D,9D, 10D,3E,3H	1E,2E,5E,8E, 10E,4H
Banksia oblongifolia	11B	2BR	4B	7C		11D,4E	3B,14B,2C,6C, 4D,6D,8D,9D, 13D,3E,1F,2F, 3F,4F	
Banksia serrata				5C,7C,2D,7D, 12D,14D,12E,5F, 1G,3G	6B		2C,9D,10D,3F	5D,3D,2E,7E, 8E,10E,4H
Banksia spinulosa		2BR,1B,7B,10B, 18B	3BR,2B,4B,6E, 1H,5H,6H,7H	5C,7C,1D,2D, 7D,14D,12E,5F 1G,3G,2H	6B		3B,14B,2C,6C, 15E,1F,2F,3F, 4F,3H	5D,1E,2E,8E, 10E,4H
Conospermum ellipticum						11E	13D	3D,7E
Conospermum longifolium subsp. *angustifolium*			1H				10D	3D,5D,2E,5E, 7E,8E,10E,4H
Grevillea buxifolia				1G			9D	5D,5E,7E
Grevillea diffusa		10B	2B,6E,1H	2D			3B,8B,6C,9D, 1F,2F,3F	5D,1E,2E,7E, 8E,10E
Grevillea linearifolia			4B	12D			3B	

Family Species	Melaleuca Thicket	Plateau Forest on Shale	Sh/SS Trans Forest	Gully Forest	Riparian Scrub	Sedgeland	Woodland/ Heath Complex	Sandstone Woodland
Proteaceae cont.								
Grevillea longifolia	11B			7C,12E				
Grevillea mucronulata		2BR	3BR,1H,5H,6H, 7H	5B,5C,7C,2D, 7D,12D,14D,12E, 5F,1G,2H	6B,13E,5G		15E	2E,8E
Grevillea oleoides				7C,	2G	4E	3E	
Grevillea sericea		2BR,7B	3BR	5C,12D,12E,5F		11D,9E	2C,6D,8D,9D, 10D,13D,15E,2F, 4F	
Grevillea sphacelata			5H	5F			8B,14B,6C,4D, 9D,10D,2F,3F, 4F,3H	3D,5D,2E,5E, 7E,10E,4H
Hakea dactyloides			2B,4B,6H	12D			3B,8B,14B,2C, 6C,4D,6D,8D, 9D,10D,13D,3E, 15E,1F,2F,3F, 4F,3H	3D,5D,1E,2E, 5E,7E
Hakea dactyloides(ss)				7C,1G				8E,10E
Hakea propinqua		9D,10D,12D						
Hakea salicifolia	1BR			2D	2G			
Hakea sericea		4G	3BR,4B,6E,1H, 6H	5C,7C,2D,12E, 5F,1G	6B,13D,5G		3B,2C,15E,1F, 3F,4F,3H	5D,1E,2E,5E, 7E,8E,10E
Hakea teretifolia						11D,4E,9E	4D,6D,8D,10D, 13D,3E,2F	
Isopogon anemonifolius		2BR,7B,10B	3BR,2B,4B,1H, 5H,6H,7H	5C,7C		11D	3B,8B,14B,2C, 4D,6D,8D,9D, 10D,3E,15E,1F, 3F,4F,3H	3D,5D,1E,2E, 5E,7E,8E,10E, 4H
Isopogon anethifolius					2G	11E		
Lambertia formosa		2BR	3BR	5B,5C,7C,2D, 7D,3G		11D	3B,14B,2C,6C, 4D,8D,9D,10D, 3E,15E,1F,2F, 3F,4F,3H	3D,5D,2E,5E, 7E,8E,10E,4H
Lomatia myricoides			7C	6B,13E,2G,5G				
Lomatia silaifolia		2BR	6E,5H,7H	5B,5C,1D,2D, 7D,12D,14D,12E 5F,1G,3G,2H	3B,6B,2C,5D		9D,3E,2F,3F	5E,7E,8E,10E, 4H
Persoonia lanceolata				7C			8B,6D,8D,1F	2E
Persoonia laurina subsp. *laurina*				7D,3G				

Family Species	Melaleuca Thicket	Plateau Forest on Shale	Sh/SS Trans Forest	Gully Forest	Riparian Scrub	Sedgeland	Woodland/ Heath Complex	Sandstone Woodland
Proteaceae cont.								
Persoonia levis		1B,15B,18B	2B,4B,6E,1H, 5H,6H,7H	5B,5C,2D,7D, 12D,14D,12E,5F, 1G,3G,2H	6B,13E	11D	3B,2C,9D,10D, 13D,3E,2F,3F, 4F,3H	3D,5D,1E,2E, 5E,7E,8E,10E, 4H
Persoonia linearis	11B	1B,7B,12B,15B, 16B,18B,4G	2B,1H,5H,7H	5B,1D,7D,14D, 5F,1G,3G,2H	6B,13E			5D,7E
Persoonia pinifolia				5B,5C,7C,2D, 12D,12E	13E		4D,6D,9D,10D, 13D	5E,8E
Petrophile pulchella				12E	2G			3D,9D
Petrophile sessilis		2BR	3BR,2B,4B,1H, 5H	7C,2D,7D,5F	6B	11D,4E	3B,8B,14B,2C, 6C,4D,6D,8D,9D, 10D,13D,3E,15E, 1F,2F,3F,4F,3H	1E,2E,5E,7E, 8E,10E,4H
Stenocarpus salignus	17B				5G			
Symphionema paludosum						4E,9E		
Telopea speciosissima				5C,7D	6B,5D			7E
Xylomelum pyriforme		7B		1D,7D,1G,3G				5D,2E,4H
Ranunculaceae								
Clematis aristata	17B			5B				
Restionaceae								
Empodisma minus						4E		
Leptocarpus tenax		10B				11D,4E,9E,11E	3E	7E
Lepyrodia scariosa			4B	5C,7C,2D		11D,9E,11E	3B,8B,2C,6C, 4D,6D,8D,9D, 10D,13D,3E,1F, 2F,3F,4F,3H	3D,5D,2E,5E, 8E,10E
Restio dimorphus					2G			
Restio fastigatus						11E		
Rhamnaceae								
Cryptandra amara							8B,9D,10D	10E
Cryptandra ericoides							6D,8D	
Pomaderris ferruginea				7C	6B,5G			
Pomaderris intermedia				12E	5G			
Rubiaceae								
Opercularia aspera	11B	4G		7D,12E	5G			

Family Species	Melaleuca Thicket	Plateau Forest on Shale	Sh/SS Trans Forest	Gully Forest	Riparian Scrub	Sedgeland	Woodland/ Heath Complex	Sandstone Woodland
Rubiaceae cont.								
Opercularia diphylla		13B,16B,18B						
Opercularia varia	11B	1B,10B,	4B	2D				
Pomax umbellata		2BR,10B,4G	3BR,4B,1H,5H, 7H	5B,1D,5F			1F	8E
Rutaceae								
Boronia ledifolia			5H	5B,5C,1G			2C	
Boronia parvifolia		12B,15B				11D,4E,9E		
Boronia ruppii								4H
Eriostemon australasius			1H,5H,7H	5C,1D,12D,5F, 1G,3G			8B,2C,4D,9D, 10D,15E,1F,3F, 4F,3H	3D,5D,2E,5E, 7E,8E,10E,4H
Eriostemon scaber subsp. *scaber*				7C,3G,2H				
Phebalium dentatum					6B,5G			
Phebalium diosmeum				7C				
Phebalium squamulosum subsp. *squamulosum*		17B			12D			
Ziera fraseri subsp. *B*				12D				
Ziera pilosa				2D,7D,12D	6B			
Santalaceae								
Exocarpus strictus		1B,7B,16B,18B 4G	5H	5C				7E
Omphacomeria acerba							8B	
Sapindaceae								
Alectyron subcinereus	17B							
Dodonaea triquetra	11B	10B	5H	5B,7C,12D,1G, 3G,2H	5G			
Schizaeaceae								
Schizaea bifida			4B	2D,12D,5F			6C,4D,8D,3E, 1F	5D,1E,5E,7E
Selaginellaceae								
Selaginella uliginosa	11B					4E,9E	3E	
Sinopteridaceae								
Cheilanthes sieberi		9B,10B,12B,15B, 18B,3G	3BR					

Family Species	Melaleuca Thicket	Plateau Forest on Shale	Sh/SS Trans Forest	Gully Forest	Riparian Scrub	Sedgeland	Woodland/ Heath Complex	Sandstone Woodland
Smilacaceae								
Smilax glyciphylla				5C,2D,7D,12D, 14D,12E,1G,3G, 2H	6B,13E,5G			
Solanaceae								
**Solanum nigrum*	17B							
Solanum prinophyllum	17B							
Solanum pungetium	11B	9B						
Stackhousiaceae								
Stackhousia nuda							6D	
Stackhousia viminea		18B,3C		2D,12D,12E			9D	
Sterculiaceae								
Lasiopetalum ferrugineum var. *ferrugineum*	11B			7C,2H	2G,5G			8E
Lasiopetalum macrophyllum				3G				
Lasiopetalum parviflorum							10D	
Stylidiaceae								
Stylidium graminifolium		2BR,10B	4B	5C,12E	13E	11D,4E,9E,11E	2C,6C,2F,3F	1E,5E,8E,10E
Stylidium laricifolium				3G				
Stylidium lineare		12B					3B,8B,14B,4D, 6D,8D,9D,10D, 13D	3D,5D
Stylidium productum			6H	1D,2D,7D,14D	6B			
Thymelaeaceae								
Pimelea linifolia	11B	2BR,7B,10B,18B	3BR,2B,1H,5H, 6H	5C,7C,7D		11D,4E,9E,11E	3B,14B,2C,4D, 6D,8D,10D,3E, 1F,2F,3F,4F,3H	3D,1E,2E,5E, 6E,7E,4H
Tremandraceae								
Tetratheca ericifolia							1F	10E,4H
Tetratheca neglecta			2B	5C,14D			2C,8D,9D,10D	3D,5D,1E,2E, 7E
Violaceae								
Hybanthus monopetalus				1G				
Viola hederacea	1BR,11B,1C,4C	9B,10B,12B,13B						

Family *Species*	*Melaleuca* *Thicket*	*Plateau Forest* *on Shale*	*Sh/SS Trans* *Forest*	*Gully* *Forest*	*Riparian* *Scrub*	*Sedgeland*	*Woodland/* *Heath Complex*	*Sandstone* *Woodland*
Xanthorrhoeaceae								
Xanthorrhoea arborea				5B,7C,1D,2D, 12D,14D,5F,3G	6B,13E			
Xanthorrhoea concava		2BR,10B,12B	2B,5H	1D,2D,7D,5F	6B		4D,3H	3D,5D,5E,7E, 8E,10E
Xanthorrhoea media			6E,1H,7H	7C,12D	6B	11E	3B,8B,2C,4D, 15E,1F,4F,3H	3D,5D,1E,2E, 7E,8E,10E,4H
Xanthorrhoea resinifera		1B,7B,16B	3BR,4B,6H	5C		11D,4E	14B,6C,6D,8D, 9D,13D,3E,2F	
Xyridaceae								
Xyris gracilis						11D	4D,6D,8D,9D, 10D,13D	7E
Xyris gracilis ssp.laxa							6D	
Xyris operculata						9E		
Zamiaceae								
Macrozamia communis		1B						
Macrozamia spiralis		15B,18B						

Breeding system and fruit development in *Persoonia juniperina* (Proteaceae)

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Experimental hand pollinations were used to examine factors that influence fruit production in *Persoonia juniperina* (Proteaceae). Assessment of the breeding system indicated no clear pre-zygotic barriers to self-fertilisation. Rates of pollen tube growth and numbers of pollen tubes were similar after selfing and outcrossing. Plants also clearly had the capacity to produce fruit from selfing, although there was some evidence of inhibition in the development of selfed zygotes. More fruit were initiated after cross-pollination, and rates of abortion were greater after selfing, resulting in lower final fruit set. Inhibition of selfed fruit is most probably exhibited post-zygotically since the percentage of ovules penetrated did not differ between treatments. However, at this stage it is difficult to differentiate between late-acting self-incompatibility and genetic load. Supplementary hand pollinations did not increase numbers of pollen tubes or percentage fruit set above natural levels, indicating that plants in the population were not pollen limited. These results contrast with those found in most other species of Proteaceae.

Introduction

The Proteaceae comprises a diverse family of woody perennial plants that are found primarily in Australia and South Africa (Collins & Rebelo 1987). The reproductive biology of members of this family has been the subject of many studies over the past two decades (see Goldingay & Carthew 1998). In Australia there are some 1100 species distributed among more than 46 genera, and the genus *Banksia* has predominated in studies done so far. Twenty one studies on stigma receptivity, breeding systems, selective fruit abortion and mating systems have been conducted on the genus *Banksia*, compared with 16 for all other genera combined (Goldingay & Carthew 1998). As a consequence, many of the generalisations about the family have been based on a limited number of similar species. We will not adequately understand the reproductive biology of this family until species from other genera are studied.

One aspect of the reproductive biology of the family Proteaceae that has been investigated in some detail is the breeding system. Several plant traits indicate that flowers are likely to receive considerable amounts of self (geitonogamous) pollination. Inflorescences are often large and made up of many flowers, a number of which may be open at the same time. It is usual for more than one inflorescence to be open at one time on a plant (Carthew 1993). Consequently, pollinators tend to visit several flowers on an inflorescence and often several inflorescences on a plant (Vaughton 1990, Carthew 1994). Despite these observations, investigations on breeding and mating systems indicate that most members of the family preferentially cross fertilise.

Available allozyme data show extremely high levels of outcrossing (Scott 1980, Carthew et al. 1988, Vaughton & Carthew 1993, Krauss 1994a), and experimental hand pollinations have generally indicated either pre- or post-zygotic selection against self pollen (Whelan & Goldingay 1989, Fuss & Sedgley 1991, although see Harriss & Whelan 1993).

The genus *Persoonia* consists of some 98 species, and members are found in many regions of Australia (Weston 1995). Several attributes of members (e.g. lack of a distinctive inflorescence, lack of pollen presenter, invertebrate pollinators: Bernhardt & Weston 1996) indicate that the reproductive biology of this genus may differ from most other members of the family. However, the reproductive biology of only two species has been reported (Krauss 1994b, Trueman & Wallace 1999). In the present study we examined several factors which influence fruit set in a third species, *Persoonia juniperina*.

Methods

Study system

Persoonia juniperina (Prickly Geebung) is a small, dense shrub reaching up to 2 m in height. It is a member of the Proteaceae and is commonly found on sandy soils in heathlands in parts of New South Wales, Victoria, South Australia and Tasmania. Flowering occurs during summer mainly between January and March. The flowers are yellow and hermaphroditic. Most plants have only a few flowers open at one time. Unlike most other members of the Proteaceae, flowers do not have a pollen presenter. The perianth is cylindrical, with four segments that curl back when the flower opens. An anther remains attached to each of these segments. The style is thick and straight, and the stigma is located at the tip, projecting beyond the anthers. Styles are 6–9 mm long, and are persistent. Flowers are most likely insect-pollinated, although few insects have been seen visiting flowers. Flowers have a single ovary, and the fruit is a succulent drupe c. 8 mm diameter, with two seeds.

This study was conducted in heathland vegetation at Horsnell Gully Conservation Park, east of Adelaide, South Australia (34°56'S, 138°42'E). Field work was conducted during the flowering seasons of 1993 and 1995.

Pollen tube growth

Hand pollinations were used to determine amounts and rates of pollen tube growth after self- and cross-pollination and to compare these to pollen tube growth for open-pollination and supplementary pollination. In 1993, flowers were allocated to one of four treatments:

i) self-pollination: flowers were bagged with fibreglass mesh and pollinated with their own pollen.

ii) cross-pollination: flowers were bagged, emasculated and then pollinated with pollen from another plant at least 5 m away.

iii) open-pollination: flowers were left open to natural pollination.

iv) supplementary pollination: cross-pollen was added to flowers left open to natural pollination.

For the self- and cross-pollination treatments, each flower was pollinated once, by hand, rubbing a freshly dehisced anther containing many pollen grains across the top of the stigma. Seven different plants were used as recipients for hand pollinations, with between two and seven used for each treatment, depending on the availability of flowers. Flowers were collected either 2 h, 4 h, 8 h, 16 h, or 48 h after pollination and immediately placed into fixative (three parts acetic acid to one part ethanol) to arrest pollen tube growth. Flowers from the open-pollination and supplementary pollination treatments were collected and fixed up to a week after pollination.

Self- and cross-pollination experiments were repeated in 1995, as it was found that 48 hours was not long enough for pollen tubes to reach the ovaries. For this experiment, flowers were collected either three, four or five days after pollination. We tested the ability of flowers to produce pollen tubes in the absence of pollinators via autogamy. For this, flowers were bagged prior to opening, left unmanipulated for one week after they had opened, and were then collected. All styles were prepared for fluorescence microscopy following the methodology of Carthew (1993). Ovaries were removed from styles and were dissected longitudinally before being mounted in a few drops of aniline blue solution and observed under a fluorescence microscope.

Pollen tubes were counted at 50 µm intervals down the length of the style. The distance travelled by the longest pollen tube in each flower was estimated by assuming that a pollen tube present at one 50 µm point, but not at the next ended halfway between. Values were then compared with total style length, and a mean obtained for each time after pollination. Effects of treatment and time on distance grown were analysed using two-way ANOVA of log transformed data.

Fruit set

As for pollen tubes, flowers received one of four treatments: self-pollination, cross-pollination, natural pollination and supplementary pollination. Each manipulated flower was pollinated on two occasions. Fruit development was monitored fortnightly after pollination to determine the extent and timing of fruit abortion.

Results

Pollen tube growth

Some self- and cross-pollen germinated within two hours of being placed on the stigmatic surface, and most flowers contained at least one pollen tube at four hours after pollination. In both treatments, many more pollen tubes germinated and grew down the style than could actually fertilise ovules. The greatest number of pollen tubes observed in any one flower was 35, although there were usually fewer than 20. The maximum number of pollen tubes was recorded in the lower style after 120 hours (Table 1). At this time, ovules of all flowers were penetrated, indicating that potential fruit set was 100%.

Table 1. Percentage of flowers with pollen tubes and mean number (± s.e.) of pollen tubes per flower in the upper and lower styles at different times after pollination. Experiment 1 was conducted in 1993, Experiment 2 in 1995. n is number of flowers.

	Self Pollination			Cross Pollination		
Time after pollination (h)	% flowers with pollen tubes (n)	Mean no. pollen tubes/flower Upper style	Lower style	% flowers with pollen tubes	Mean no. pollen tubes/flower Upper style	Lower style
Experiment 1:						
2	73 (11)	2.27 ± 0.7	0	36 (11)	0.55 ± 0.3	0
4	100 (10)	6.4 ± 0.8	0.2 ± 0.2	80 (10)	3.7 ± 1.2	0
8	70 (10)	5.3 ± 1.8	0.1 ± 0.1	100 (10)	10.4 ± 2.0	0
16	89 (9)	14.56 ± 3.7	0	100 (10)	9.5 ± 0.9	0.1 ±0.1
48	90 (11)	16.73 ± 3.3	0.73 ± 0.3	100 (11)	10.09 ± 2.1	1 ± 0.4
Experiment 2:						
72	100 (10)	6.1 ± 0.9	3.8 ± 0.4	100 (10)	8.0 ± 0.7	6.2 ± 0.8
96	100 (10)	6.5 ± 0.9	4.3 ± 0.5	100 (10)	8.4 ± 1.2	6.8 ± 0.9
120	100 (10)	8.4 ± 0.9	6.3 ± 0.5	100 (10)	8.8 ± 1.8	7.2 ± 1.6

Self- and cross-pollen tubes grew at similar rates for the entire length of the style (Fig. 1, Table 2). Distances grown tended to increase gradually between 2 and 48 hours, and then doubled between 48 and 72 hours (Fig. 1). It generally took between 72 and 96 hours for pollen tubes to reach the ovaries.

The autogamy, open and supplemented pollinations had similar numbers of flowers with pollen tubes (Table 3: $G = 0.55$, $df = 2$, $p > 0.95$). However, the autogamy pollinations had significantly fewer pollen tubes per flower than the other pollinations (Kruskal-Wallis test: $H = 25.67$, $df = 2$, $p < 0.005$) and fewer flowers with their ovules penetrated.

Table 2. Two-way ANOVA for the effects of time and treatment on pollen tube growth after self- and cross-pollination. Data were log-transformed. Flowers from Experiment 1 were collected 2, 4, 8, 16 and 48 h after pollination, and those from Experiment 2 were collected 72, 96 and 120 h after pollination.

	Experiment 1				Experiment 2			
Source	df	MS	F	p	df	MS	F	p
time	4	0.057	15.235	0.0001	2	0.001	3.184	0.049
treatment	1	0.002	0.565	0.454	1	0.000	0.003	0.959
time*treatment	4	0.006	1.664	0.165	2	0.000	0.003	0.997
error	93	0.004			54	0.000		

Table 3. Pollen tube growth and ovule penetration after different pollination treatments. Pollen tube numbers are means (± s.e.) in the upper style.

Treatment	Autogamy	Open	Supplement	P
No. flowers	25	36	26	
% flowers with pollen tubes	88	89	100	NS
Mean no. pollen tubes/flower	3.14 ± 0.31	15.06 ± 2.22	12.81 ± 1.88	< 0.005
% flowers with at least one ovule penetrated	48	72	NA	

Table 4. Fruit production following different pollination treatments. n is the number of plants.

Treatment	Self	Cross	Open	Supplement	P
No. flowers (n)	50 (3)	50 (3)	70 (3)	24 (5)	
% fruits initiated	50	72	61.4	83.3	< 0.05
% fruits matured	12	30	41.4	37.5	< 0.01
% fruits aborted	76	58	33	55	< 0.01

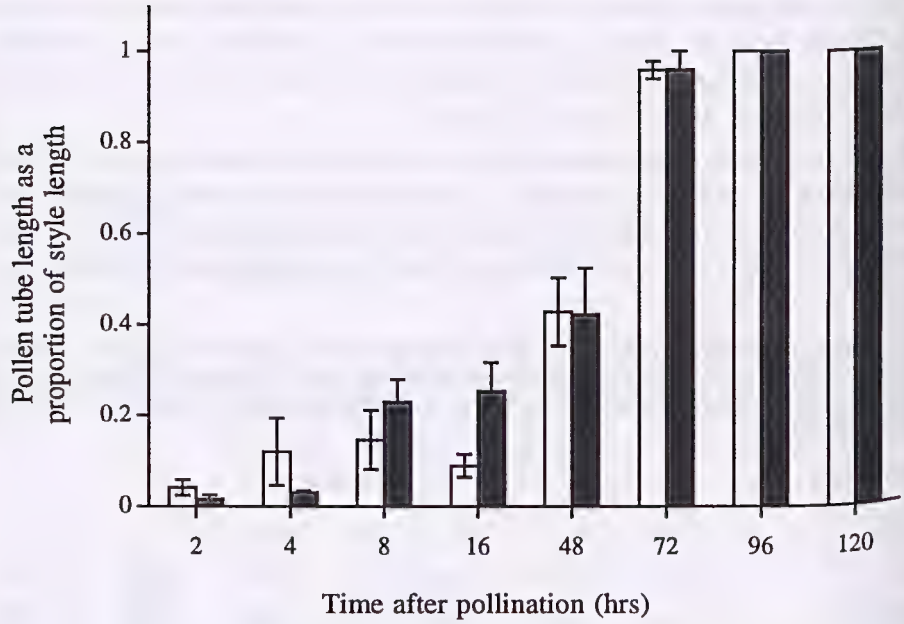

Fig. 1. Distance grown by the longest pollen tubes as a function of style length (mean ± s.e) at various times after self (open bars) and cross (filled bars) pollinations.

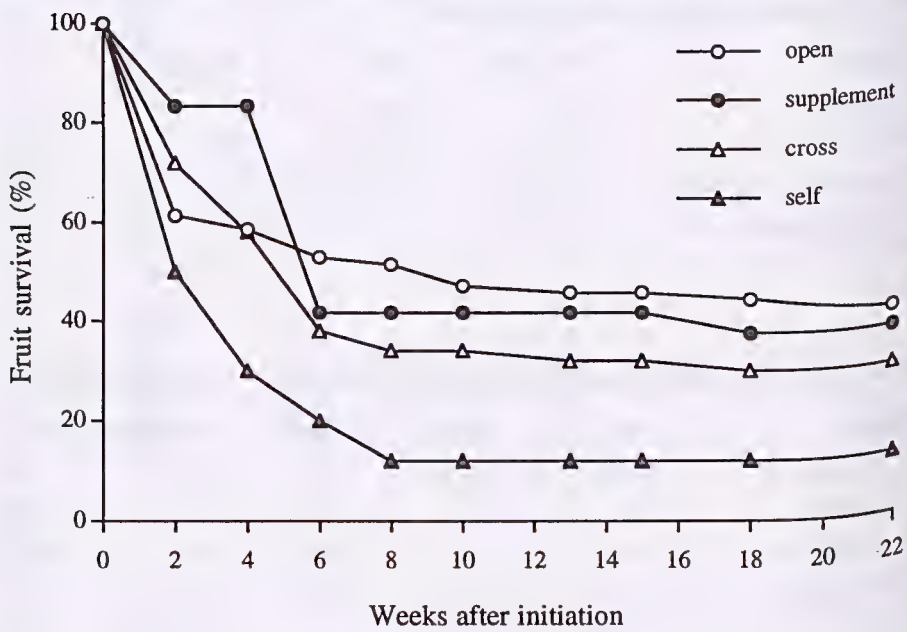

Fig. 2. The percentage of fruit surviving over time for open, supplement, cross and self pollinations. T_o = 3–4 weeks post-pollination.

Fruit set

All pollinations produced some fruit and the percentage of fruits initiated ranged from 50% for selfed flowers to 83% for supplemented flowers (Table 4). The percentage of fruits initiated which subsequently aborted was significantly different among pollinations ($X^2 = 12.93$, df = 3, $p < 0.01$). The highest rate of abortion occurred in self-pollinated flowers (76%) and the lowest in open-pollinated flowers (33%). The percentage of fruits which eventually matured was also significantly different among pollinations ($X^2 = 12.6$, df = 3, $p < 0.01$). Self-pollination produced the fewest fruits, while open pollination produced the most.

Fruit swelling was first detected three to four weeks after pollination. From then, the number of maturing fruits declined steadily over time, until week eight, by which time fruit abortion had slowed considerably (Fig. 2). Self-pollination showed the fastest decline, while the open-pollination was much slower.

Discussion

During the present study, the only visitors observed on flowers were small ants, and these were seen infrequently. Despite the apparent lack of pollinators, most flowers left open to pollination had pollen tubes, and more than 40% matured fruit. This compares to values of 17–34% for open-pollinated *Persoonia mollis* flowers (Krauss 1994b), and 67% for *Persoonia rigida* (Trueman & Wallace 1999). However, it does contrast with most other studies which have mostly documented very low levels of fruit set in this family, usually less than 5% (Ayre & Whelan 1989). In other more commonly studied genera such as *Banksia*, the production of flowers and fruits requires large amounts of energy, as flowers are packaged into large, showy inflorescences which turn into woody infructescences as seeds are matured. It may not be surprising that these plants have high flower:fruit ratios in comparison.

There appears to be considerable variability in breeding systems among species of Proteaceae. Many species have been shown to produce few or no seeds after selfing (e.g. *Banksia prionotes* — Collins & Spice 1986, *Banksia paludosa* — Goldingay & Whelan 1990, *Banksia ericifolia* — Goldingay et al. 1991, *Banksia menziesii* — Ramsey & Vaughton 1991, *Persoonia mollis* — Krauss 1994b, *Telopea speciosissima* — Whelan & Goldingay 1989). Others appear to be capable of relatively high levels of selfing and/or some autogamous seed production (e.g. *Banksia spinulosa* var. *neoanglica* — Vaughton 1988, *Grevillea barklyana* — Harriss & Whelan 1993, *Persoonia rigida* — Trueman & Wallace 1999). Despite this apparent variability, it seems likely that even those species capable of selfing will preferentially outcross when possible (Vaughton & Carthew 1993, Carthew et al. 1996).

In this study, *Persoonia juniperina* exhibited particularly high levels of selfing, as evidenced by both pollen tube growth and fruit production after experimental hand pollinations. This may ensure successful fruit production when pollinators are scarce. It is interesting that no differences in pollen tube growth rates were observed in selfed and outcrossed flowers during this study. This contrasts with many other studies of

self-compatible species, where self pollen tubes grow considerably more slowly than cross pollen tubes (e.g. Hessing 1989, Aizen et al. 1990, Harriss & Whelan 1993). Interestingly, although only two other species of *Persoonia* have been studied to date, there are obvious differences in their breeding systems. A single population of *Persoonia mollis* studied was found to be highly outcrossed, with almost no seed produced from selfing, and no pollen tubes evident in the ovules (Krauss 1994b). In contrast, *Persoonia rigida* showed no evidence of self-incompatibility, in either pollen tubes or seed set (Trueman & Wallace 1999). The population of *Persoonia juniperina* studies here appears to lie somewhere between these two extremes.

Although *Persoonia juniperina* can clearly produce seeds from self pollination, there does appear to be some late-acting selection against selfing, which probably occurs post-zygotically. The lack of differences between self and cross pollination in amounts and rates of pollen tube growth and proportions of ovules that were penetrated indicate no pre-zygotic discrimination. However, selfed flowers were less likely to initiate fruit than other pollinations, and fruit abortion was higher, resulting in significantly lower final fruit set. There are two main reasons for selection against self pollen (Seavey & Carter 1994). There may be allelic self-incompatibility, which is commonly expressed on the stigma or in the style, but may occur at the level of the ovule and perhaps even post-zygotically. However, rejection or acceptance of incompatible compared to compatible pollen should be consistent between individuals. An alternative model implicates genetic load, whereby combinations of recessive deleterious or lethal genes cause embryo abortion. This is likely to be a very common phenomenon in plants (Burbidge & James 1991). In the genetic load model, many genes are implicated, and thus expression should vary between individuals (Waser & Price 1991).

In *Persoonia juniperina* the existence of a pre-zygotic incompatibility reaction cannot be entirely ruled out at this stage, because it is difficult to observe fertilisation events. However, embryo abortion obviously plays a much more important role. It is not clear whether selection against selfing occurs through allelic self- incompatibility or because of a system of recessive lethals. The sample size was too small to determine whether there was variability between plants in their capacity to set selfed seed. Research is now needed to assess in more detail whether individual plants can and do differ in the degree to which they can self.

Several lines of evidence indicate that despite a lack of observed pollinator activity, plants in this population were not pollen limited during the year of the study. First, hand supplementation failed to increase levels of pollen tube growth or initial fruit set over that for natural pollination. Second, the percentage of fruits that were matured was similar for the two treatments. Third, most flowers from all treatments contained pollen tubes and there were usually many more pollen tubes than ovules, even at the base of styles, indicating a surfeit of pollination. This is in contrast to results from other species of Proteaceae studied so far, most of which have shown considerable pollen limitation (*Banksia paludosa* — Goldingay & Whelan 1990, *Telopea speciosissima* — Whelan & Goldingay 1989). However, most taxa studied have been outcrossing species, and may have been limited by quality of pollen rather than quantity. It is clear

that further investigations are required to elucidate the reasons for these differences. Studies on the mating system are required to determine natural levels of outcrossing, and more detailed observations on pollinators and their effectiveness are also needed.

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Ecology of Proteaceae with special reference to the Sydney region

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In Australia, the Proteaceae are a diverse group of plants. They inhabit a wide range of environments, many of which are low in plant resources. They support a wide range of animals and other organisms, and show distinctive patterns of distribution in relation to soils, climate and geological history. These patterns of distribution, relationships with nutrients and other resources, interactions with animals and other organisms and dynamics of populations in Proteaceae are addressed in this review, particularly for the Sydney region.

The Sydney region, with its wide range of environments, offers great opportunities for testing general questions in the ecology of the Proteaceae. For instance, its climate is not mediterranean, unlike the Cape region of South Africa, south-western and southern Australia, where much of the research on plants of Proteaceae growing in infertile habitats has been done.

The diversity and abundance of Proteaceae vary in the Sydney region inversely with fertility of habitats. In the region's rainforest there are few Proteaceae and their populations are sparse, whereas in heaths in the region, Proteaceae are often diverse and may dominate the canopy. Research in the region has led to an understanding of their various responses to fire, dynamics of their populations in fire-prone landscapes, interactions with animals in pollination and dispersal, and of their breeding systems. This review examines results of this research and shows that ecological research has been uneven in Australian Proteaceae, with little work done on rainforest and alpine Proteaceae.

The review reveals an enormous range of interesting features of the Proteaceae of the Sydney region. It also identifies a large number of questions about ecological and evolutionary processes that are at the cutting edge of our current knowledge. The diversity of taxa of Proteaceae, the range of habitat, soil and climatic zones they occupy, the variety of life-histories (even among populations within species), fire responses, floral morphologies, pollinator types and breeding systems combine to make this family in the region a rich 'test bed' for many of these questions.

Proteaceae and Australian ecology

Distribution and diversity

Australia has the world's greatest diversity of Proteaceae, a family of woody evergreen plants ranging from tall trees, small trees, to shrubs — some of which are prostrate. It is the only continent in which all five of the subfamilies recognised by Johnson and Briggs (1975) are represented, and confined to it are two new subfamilies recognised since 1975 (CSIRO 1995). Africa including Madagascar has representatives from only the Proteoideae and Grevilleoideae, while South and Central America have representatives from only the Grevilleoideae (Johnson & Briggs 1975). Even within Australasia, the Western Pacific and East Asia, the Sphalmioideae and Carnarvonioideae occur only in Australia (Johnson & Briggs 1975) as do the recently recognised Bellendenoideae and Eidotheoideae (CSIRO 1995). Of the tribes recognised in the family by Johnson and Briggs (1975), the only one lacking in Australia is the Proteeae, which is endemic to Africa. Johnson and Briggs (1975) identified 51 of the world's 75 genera then recognised in the Proteaceae as endemic to their super-region of Australasia, the Western Pacific and East Asia. More recently, of 80 genera recognised in the family, 46 occur in Australia with 37 entirely endemic to it, while of 1769 species in the family, 1093 occur in Australia with 1088 of them endemic to it (George 1998). In a careful analysis of species diversity of Proteaceae in areas of the Cape Floristic Region of South Africa and Western Australia's South West Botanical Province, comparable in climate and their range of habitats, Cowling and Lamont (1998) found greater diversity of species in the latter. In short, at all taxonomic levels, and on various criteria of comparison, Australia has a greater diversity of Proteaceae than elsewhere (Table 1).

In Australia, Proteaceae occur in a much wider range of habitats than in other continents. The rainforests of the wet tropics in north-eastern Queensland are remarkable in containing trees of several genera in the family, many of them with high endemism in this area at the levels of tribes and subfamilies (Johnson & Briggs 1975, 1981, Beadle 1981a, Specht 1981a, Webb & Tracey 1981, Carpenter 1994). Subtropical and warm temperate rainforests of eastern Australia have trees and shrubs of Proteaceae while cool temperate rainforest has shrubs of the family including two Tasmanian endemic monotypic genera *Agastachys* and *Cenarrhenes* (Specht et al. 1974, Johnson & Briggs 1975, 1981, Beadle 1981a). Shrubs of Proteaceae occur in alpine areas of eastern Australia, including, in Tasmania, the monotypic *Bellendena montana* (Specht et al. 1974, Johnson & Briggs 1975, Beadle 1981a), now in its own subfamily (Weston 1995b). Beyond the rainforests and alpine areas, Proteaceae extend across the continent in almost every major formation of vegetation as small trees and shrubs; Proteaceae occur in 12 of the 13 major vegetation formations recognised by Specht (1981a), apparently lacking only from chenopod low shrubland, as they are from saline coastal areas. Though they occur in monsoonal northern Australia, and in the arid and semi-arid Eremean region where they are represented almost entirely by species of *Grevillea* and *Hakea*, Proteaceae are particularly abundant as species in the sclerophyllous forests, woodlands and heaths of eastern and south-western Australia (Johnson & Briggs 1975, Beadle 1981a), particularly in south-western Australia (Johnson & Briggs 1975, Beadle 1981a, Cowling & Lamont 1998).

Table 1. Comparison of the representation of the Proteaceae in the Sydney region with Australia and other regions of the world [modified from Weston & Crisp (1996)].

	Sydney Region	Australia	Africa	Madagascar	Mainland Asia	Indonesia Philippines	New Guinea	Pacific	South America
Eidotheoideae									
Eidothea		✓							
Proteoideae									
Consopermum	✓	✓							
Synaphea		✓							
Petrophile	✓	✓							
Isopogon	✓	✓							
Stirlingia		✓							
Cenarrhenes		✓							
Beauprea								✓	
Beaupreopsis								✓	
Agastachys		✓							
Symphionema	✓	✓							
Dilobeia				✓					
Franklandia		✓							
Adenanthos		✓							
Protea			✓						
Faurea			✓	✓					
Leucospermum			✓						
Vexatorella			✓						
Diastella			✓						
Spatalla			✓						
Sorocephalus			✓						
Mimetes			✓						
Orothamnus			✓						
Paranomus			✓						
Serruria			✓						
Aulax			✓						

Table 1 cont.	Sydney Region	Australia	Africa	Madagascar	Mainland Asia	Indonesia Philippines	New Guinea	Pacific	South America
Proteoideae cont.									
Leucadendron			✓						
Bellendenoideae									
Bellendena		✓							
Persoonioideae									
Persoonia	✓	✓							
Acidonia		✓							
Garnieria								✓	
Toronia								✓	
Placospermum		✓							
Sphalmioideae									
Sphalmium		✓							
Carnarvonioideae									
Carnarvonia		✓							
Grevilleoideae									
Orites		✓							✓
Neorites		✓							
Megahertzia		✓							
Knightia								✓	
Eucarpha								✓	
Darlingia		✓							
Cardwellia		✓							
Embothrium									✓
Oreocallis									✓
Alloxylon		✓					✓		
Telopea	✓	✓							
Lomatia	✓	✓							✓
Stenocarpus	✓	✓					✓	✓	
Strangea		✓							

	Sydney Region	*Australia*	*Africa*	*Madagascar*	*Mainland Asia*	*Indonesia Philippines*	*New Guinea*	*Pacific*	*South America*
Grevilleoideae cont.									
Buckinghamia		✓							
Opisthiolepis		✓							
Grevillea	✓	✓					✓	✓	
Hakea	✓	✓							
Finschia							✓	✓	
Helicia	✓	✓			✓	✓	✓	✓	
Xylomelum	✓	✓							
Triunia		✓							
Hollandaea		✓							
Macadamia		✓				✓			
Panopsis									✓
Brabejum			✓						
Hicksbeachia		✓							
Athertonia		✓							
Heliciopsis					✓	✓			
Virotia								✓	
Catalepidia		✓							
Malagasia				✓					
Gevuina		✓					✓		✓
Turrillia								✓	
Sleumerodendron								✓	
Kermadecia								✓	
Euplassa									✓
Roupala									✓
Floydia		✓							
Lambertia	✓	✓							
Banksia	✓	✓					✓		
Dryandra		✓							
Musgravea		✓							
Austromuellera		✓							

Interactions with other organisms

Plants in the Proteaceae in Australia support a wide range of other species. Many species of invertebrates and vertebrates in Australia draw food and other resources from plants of the family. In some, galls are formed by various insects, including leaf-pit galls by some hemipterans, *Cecidopsylla putealis* in *Banksia* and by a species of *Aacanthocnema* in *Hakea* (CSIRO 1991), while an endemic species of wasp, *Mesostoa kerri*, causes stem galls in *Banksia marginata* (Austin & Dangerfield 1998). Australian aleyrodids (white flies) colonise plants of Proteaceae and other families (CSIRO 1991). Beetles of the genus *Idaethina* are found in seeds of Proteaceae (CSIRO 1991). In some *Banksia* species, curculionid (weevil) and lepidopteran larvae consume seeds (Scott 1982). Leaves are mined between the upper and lower epidermis by some lepidopteran larvae, while other lepidopteran larvae tunnel in woody stems and fruits, and yet others feed while exposed on foliage (CSIRO 1991). Black cockatoos break open woody infructescences of some species of *Banksia* apparently in search of insect larvae tunnelling within them (Scott & Black 1981). Flowers, occurring in many Proteaceae in showy inflorescences, are visited by birds, fruit bats and blossom bats, sugar gliders and feather-tailed gliders, honey and pygmy possums, antechinuses, native rats, and a range of insects including moths, beetles, and bees, many feeding on the often abundant nectar, and some acting as effective pollinators (Maynard 1995). Many forage widely, but some are specific; colletid bees of the subgenus *Cladocerapis* of *Leioproctus* forage only on the flowers of *Persoonia* (Michener & Houston 1991). Moreover, most *Persoonia* species are pollinated by a limited range of native bee visitors. In a survey of pollen loads of all insects caught on flowers of 21 *Persoonia* taxa, Bernhardt & Weston (1996) found that over 50% of insects were carrying pollen only of the *Persoonia* species on which they were caught.

Some Proteaceae have succulent fruits, some of which are taken by mammals, including fruit bats, and by birds (Douglas 1995). Thus, Proteaceae are not only important components themselves of Australia's biodiversity but may be key components in supporting the life of various species of its animals, and probably also species of its fungi, bacteria and other micro-organisms.

Nutrient uptake and allocation

Many plants in the Proteaceae have a remarkable capacity for uptake of scarce nutrients, moving them between various plant organs, and storing them in high amounts in seeds and organs such as lignotubers from which growth may be renewed. Effective uptake of scarce inorganic nutrients by most plants in the family growing on impoverished soils appears to be related to the production and function of clusters of fine roots, the so-called proteoid roots, particularly just below the surface of the soil (Purnell 1960, Jeffrey 1967, Lamont 1972a & b, 1976, 1981, 1982, 1984, Pate 1994, Jeschke & Pate 1995, Pate et al. 1998), though proteoid roots are absent in the subfamily Persoonioideae (Weston 1995a) and also in *Symphionema* and *Agastachys* (Lee 1978).

Translocation and storage of inorganic nutrients in plants of Proteaceae may be in part related to the large and more complex rays and plentiful parenchyma associated with vessels shown by Chattaway (1948) to occur in their wood. She examined the wood of

a wide range of species in the family and found large rays in all except some in the Persoonioideae which had small rays, but, even among the Persoonioidae, some species in all genera studied had some very large rays in their wood (Chattaway 1948). With such a structure, the wood of Proteaceae can be expected to be of low density, as Boas (1947) reported in *Cardwellia sublimis*, *Grevillea robusta* and *Orites excelsa* and Beadle (1966) in *Banksia serrata*.

Storage of polyphosphate was shown by Jeffrey (1964, 1968) in the roots of some heathland species of Proteaceae. Translocation of phosphorus was shown by Beadle (1968) in the wood of *Orites excelsa*; it was the only species among the rainforest species he examined that was Proteaceae and in which considerable amounts of phosphorus were withdrawn from the xylem as it matured into heartwood. Translocation of inorganic nutrients, particularly of phosphate, occurs in a marked way in the differentiation and senescence of leaves in many plants of the family. Significant translocation of nutrients must occur during the differentiation of the high amount of sclerenchyma and other non-living tissues that are laid down during the maturation of leaves of many plants in the family.

Many Proteaceae are sclerophyllous, having mature leaves with much lignin in sclerenchyma, cutin in thick cuticles, or silica present, especially in epidermal cell walls, the three characteristics occurring together in several Proteaceae (Beadle 1966). Sclerophyllous plants occur particularly on infertile soils (Beadle 1954, 1962, 1966), but several rainforest Proteaceae are also at least somewhat sclerophyllous (Beadle 1966, Johnson & Briggs 1975, Carpenter 1994). A consequence of differentiating sclerophyllous leaves is often slower growth than in plants with soft, mesomorphic leaves (Beadle 1968), but a much higher production of dry matter per unit weight of phosphorus absorbed by the plant (Grundon 1972), lower proportions of phosphorus in the dry mass of the leaves (Beadle 1954), and often long-lived leaves, up to ten years in one species of *Banksia* (Witkowski et al. 1992).

During the senescence of leaves of sclerophyllous Proteaceae, significant translocation of nutrients occurs, especially in the withdrawal of phosphorus from the leaves (Beadle 1968, Specht 1981b, Pate & Dell 1984). Perhaps the most spectacular transfer of nutrients in the Proteaceae is in the provisioning of embryos in seeds. No starch is stored in them, but a very high proportion of their dry mass is protein with oil abundant in the seeds of most species (Kuo et al. 1982, Pate et al. 1986) and very high amounts of phosphorus (Grundon 1972, Pate et al. 1986, Lamont & Groom 1998). The amounts of the plant's phosphorus and nitrogen allocated to seeds in many plants in the Proteaceae may be disproportionately very high compared to carbon allocated to them; this was certainly shown to be so in one species of *Banksia* by Witkowski and Lamont (1996). In short, provisioning of their embryos and other aspects of the nutrition indicate that plants in the Proteaceae as a whole tend to fall into Grime's (1974) category of stress-tolerators, inhabiting environments where at least one resource for growth is in low supply.

In Australia, the Proteaceae are a diverse group of plants. They inhabit a wide range of environments, many of which are low in plant resources. They support a wide range of animals and other organisms, and show distinctive patterns of distribution in

relation to soils, climate and geological history. These patterns of distribution, relationships with nutrients and other resources, interactions with animals and other organisms and dynamics of populations in Proteaceae are addressed in this review, particularly in the Sydney region.

Patterns of distribution in the Proteaceae

Patterns of distribution in the Proteaceae in Australia are related to variation in soils and climate. Modern climatic patterns and patterns of distribution of Proteaceae in Australia are related to its geological history.

In the early Tertiary, though Gondwana had broken up in the Cretaceous with Africa and India drifting northward, the southern edge of Australia was broadly attached to Antarctica, while South America was narrowly connected (Barlow 1981). Though Australia was then in relatively high southern latitudes, with sea temperatures much warmer than now at such latitudes, its climate was generally warm and wet with rainforests in Central Australia and what are now arid or semi-arid areas in south-eastern Australia (Martin 1998). At such high latitudes, the seasonal variation in light available for photosynthesis is great with long days in summer and very short days in winter. The fossil record indicates a continuous presence of Proteaceae in Australia since the Cretaceous (Johnson & Briggs, 1981, Hill et al. 1995, Hill et al. 1999), and, with such a long history under so seasonal a light regime, it is perhaps no surprise that the capacity for uptake, storage and translocation of resources is so well developed in many Australian Proteaceae. Seasonal separation between uptake and use of resources occurs in some Australian Proteaceae, for example in *Banksia prionotes* (Pate et al. 1998).

Johnson and Briggs (1975) argued that some patterns of distribution in Australian Proteaceae directly relate to distributions of Proteaceae in the early Tertiary. Among these patterns is the occurrence of *Orites*, *Lomatia* and *Gevuina* in Australia shared with South America; at the subtribal level, the Embothriinae is represented in Australia and South America and the Macadamiinae has representatives in them both and in South Africa. Another of these patterns is the occurrence of the strictly rainforest genera of diverse lineages within Proteaceae that are endemic to the wet tropics of north-east Queensland. Another may be the occurrence of the Tasmanian endemic monotypic genera *Agastachys*, *Cenarrhenes* and *Bellendena*, the first two closely associated with cool temperate rainforest and the third an alpine species. These Tasmanian genera and the endemic genera of north-eastern Queensland have probably remained in the same sort of habitats as they occupied in the early Tertiary. In these places, they have escaped the general drying of the continent as it detached from Antarctica and drifted north into lower latitudes during the Tertiary (Martin 1998).

Differentiation of highly sclerophyllous plants in Proteaceae onto infertile soils and less sclerophyllous ones onto more fertile soils is of long standing in Australia (Johnson & Briggs 1975). Beadle (1981b) suggested that such xeromorphic plants on infertile soils in moist climates were most widely distributed during wet periods in the Miocene, and, then, as the modern arid zone formed, contracted into two main

assemblages, one in the east on Triassic sandstones centred on Sydney and the other in south-western Western Australia. These sclerophyllous Proteaceae include a great many species, particularly in the south-west, and have five genera that are endemic to the south-west and two almost so, with only one genus endemic to the east (Johnson & Briggs 1975), and only slight evidence of recent interchange between west and east (Nelson 1981), presumably along sand dunes in the Bight during periods of low sea levels in the Quaternary. Despite their obviously high species diversity, particularly in the south-west (Cowling & Lamont 1998), they do not show the same degree of generic diversity at high taxonomic levels as the Proteaceae of the north-eastern rainforest of the Queensland wet tropics (Johnson & Briggs 1975, 1981), and, unlike some Proteaceae on the east coast, those in the south-west show no connections with extra-Australian taxa in the Proteaceae.

Though most Proteaceae appear to have become more restricted in their distribution by the onset of aridity during the late Tertiary, some species of two genera, *Grevillea* and *Hakea*, survive in the Australian arid zone (Johnson & Briggs 1975). Both *Grevillea* and *Hakea* are particularly rich in species; indeed ranking third and fourth respectively behind *Acacia* and *Eucalyptus* (sensu lato) in genera with the most species in the Australian flora (Beadle 1981b). *Grevillea* and *Hakea* have the widest ecological range of any genera in the Proteaceae in Australia, occurring in rainforest, monsoonal woodlands of the north, through the great variety of temperate sclerophyll forests and woodlands, to open shrubland and low woodlands of the arid zone. Nevertheless, the vast majority of their species are in the sclerophyllous communities of infertile soils in mediterranean climates of south-western and southern Australia and moist climates of eastern Australia. Like the arid zone, the monsoonal region of northern Australia has a climate of recent origin, and is relatively poor in Proteaceae, both in species and genera, with five other genera beside *Grevillea* and *Hakea*, most of them with many more species elsewhere in Australia (Johnson & Briggs 1975).

In summary, the current distribution of Australian Proteaceae seems to reflect ancient patterns of distribution with most taxa associated with rainforests or with infertile soils under climates of relatively high non-seasonal or winter rainfall. Sclerophyllous taxa are particularly numerous on infertile soils in winter-rainfall areas of south-western Australia. Early Australian Proteaceae would have existed under a highly seasonal climate, in terms of light at least. Only a few taxa survive in the arid zone of Central Australia and monsoonal regions of northern Australia, whose present climates have both originated in relatively recent geological times.

The Sydney region, like much of the rest of eastern Australia, would not have had as great a change of climate through the Tertiary as most of the rest of Australia (Martin 1998). It possesses a large area with infertile soils and thus is rich in species of sclerophyllous Proteaceae. There are some soils of moderate fertility over basalt, shales and some alluvia, and there is some variation in climate across the region, and the distribution of its Proteaceae can be related to variation in soils and climate.

Ecological distribution of Proteaceae in the Sydney region

Climate and soils each vary across the Sydney region and variations in the regional vegetation have been related to them and other features of its landscape (Pidgeon 1937, 1941, Burrough et al. 1977, Benson & Howell 1990). The relative importance of Proteaceae in the vegetation shows a marked inverse relationship to soil fertility; the poorer the fertility of a site the greater the probability of a high number of species and abundance and cover of plants of Proteaceae in its vegetation. This trend appears to hold irrespectively of variation across the region in rainfall and temperatures.

Rainforest Proteaceae

In the region's rainforests, which occur on patchily distributed sites of at least moderate fertility, as indicated by Beadle (1954, 1962), there are few Proteaceae; some patches lack them completely. *Helicia glabriflora* occurs in southern rainforests, on fertile soils near Robertson and Minnamurra (Floyd 1989). In rainforest on the basalt cap of Mount Wilson, a few *Banksia integrifolia* subsp. *monticola* occur (Brough et al. 1924). *Lomatia myricoides* occurs on Mount Wilson, in the tall eucalypt forest at the junction of the basalt and underlying sandstone and in rainforest on sandstone on sheltered south-eastern slopes (McLuckie & Petrie 1926). *Lomatia myricoides* also occurs in remnant gallery rainforest along the banks of some creeks in northern parts of the region (Benson 1986), while, in central coastal parts of the region, it occurs together with *Stenocarpus salignus* along creek lines on sandstone in gallery rainforest of small trees and shrubs (Benson & Howell 1990, 1994), whereas along the Ettrema creeks and gorges and gullies, the most frequently observed rainforest species were *Livistona australis*, *Synoum glandulosum*, *Diospyros australis* and *Stenocarpus salignus* (D. Black, pers. obs.).

Proteaceae of other habitats

From the rainforests, the importance of Proteaceae increases in the region's eucalypt forests and woodlands. However, the forests and woodlands on shale soils have few Proteaceae; *Grevillea juniperina* occurs on Wianamatta shales (Beadle et al. 1972), and *Persoonia laurina*, *Persoonia linearis* and *Hakea sericea* occur on both shale and sandstone soils (Beadle et al. 1972, P.H. Weston, pers. comm.). A few species appear to be most abundant on the sandstone-shale interface, for example *Persoonia nutans*, *Persoonia bargoensis* and *Grevillea parviflora* (P.H. Weston pers. comm.). It is on the region's sandstone soils that most of its Proteaceae occur, though many also occur on dune sands and lateritic surfaces. Beside eucalypt forests and woodlands, sandstone areas also carry sclerophyllous scrub and heathlands where Proteaceae may dominate the canopy. For instance, there is a marked contrast between the single species of Proteaceae, *Banksia integrifolia*, in rainforest on the basalt summit of Mount Wilson (Brough et al. 1924) and the nineteen species of Proteaceae, covering nine genera, Petrie (1925) mentioned in data from the surrounding sandstone vegetation. Though most of the region's Proteaceae occur in habitats on Triassic sandstones, some species extend into habitats over other rocks. In data of Benson and Keith (1990), given on the reverse side of their map of the vegetation of the Wallerawang area, *Persoonia linearis*

and *Hakea dactyloides* are recorded as widespread extending well beyond areas of Triassic sandstone; this is also evident in data from the Burragorang area where *Banksia spinulosa* subsp. *spinulosa* is also widespread (see Appendix A of Fisher et al. 1995).

Local endemism

The high diversity of Proteaceae in infertile sites indicates a long history of their occupation of such sites in the region, as suggested by Beadle (1981b) and Johnson and Briggs (1975, 1981). Another aspect of their long history is the high degree of local endemism among Proteaceae in such sites, see p. 97 of Benson & Fallding (1981); Table 3, p. 485, of Benson (1986); Table 4, pp. 140–141, of Keith & Benson (1988); Table 4, pp. 332–333, of Benson & Keith (1990); Table 14, p. 590, of Benson (1992); Table 5, p. 776, of Benson & Howell (1994); and Table 4, p. 186, of Fisher et al. (1995). The grevilleas with 'tooth brush' inflorescences in the Sydney region, for example, include a number of similar species which occupy highly specific habitats, and many of which are rare, with restricted ranges (e.g. *Grevillea macleayana, Grevillea longifolia, Grevillea caleyi, Grevillea acanthifolia, Grevillea rivularis* and *Grevillea aspleniifolia*) (McGillivray 1993, Pickup 1999, T. Llorens pers comm.)

The Sydney region has a high degree of diversity and local endemism in its Proteaceae in infertile sites, perhaps higher for such scleromorphic Proteaceae than elsewhere in eastern Australia, but not as high as south-western Australia, where infertile habitats have particularly high degrees of diversity of Proteaceae (Cowling & Lamont 1998). Though the Sydney region shares with the south-western Australia the occurrence of genera such as *Banksia, Conospermum, Grevillea, Hakea, Isopogon, Lambertia, Persoonia, Petrophile* and *Xylomelum*, the two regions have no species in common. The genera *Helicia, Lomatia, Stenocarpus, Symphionema* and *Telopea* occur in the Sydney region but not in south-western Australia, while *Acidonia, Adenanthos, Dryandra, Franklandia, Stirlingia, Strangea* and *Synaphea* occur in south-western Australia but not in the Sydney region. *Strangea* occurs elsewhere in New South Wales and Queensland, and *Adenanthos* occurs in South Australia and Victoria though most of its species are endemic to south-western Australia, while the genera *Acidonia, Dryandra, Franklandia, Stirlingia*, and *Synaphea* are endemic to south-western Australia. The Sydney region is poor in rainforest Proteaceae with only *Helicia glabriflora* and the rainforest sub-species of *Banksia integrifolia* which are each at the southern edges of their distributions in the region, and *Stenocarpus salignus* and *Lomatia myricoides*. It lacks any alpine Proteaceae.

Thus, although the Sydney region does not give a fully representative sample of Australian Proteaceae, lacking alpine and being poor in rainforest Proteaceae, it has a good representation of sclerophyllous Proteaceae of infertile soils. They cover the same three subfamilies represented in south-western Australia, Persoonioideae, Proteoideae and Grevilleoideae. Proteaceae of the Sydney region's infertile soils display a similar range of fruits and infructescences to those in Proteaceae of south-western Australia. There are fleshy drupes in *Persoonia*. There are achenes, which in *Conospermum* and *Symphionema* are shed on maturity, but in *Isopogon* and *Petrophile* are held in the scales of bradysporous cone-like infructescences. There are follicles in all the Sydney region's Grevilleoideae except *Helicia* which is confined to rainforest and has a fleshy, one-seeded fruit. The follicles in *Grevillea, Lomatia, Stenocarpus* and *Telopea*

open at maturity, while the follicles of *Banksia*, *Hakea*, *Lambertia* and *Xylomelum* are woody and, in most species, are bradysporous with their opening delayed after they mature, in some cases until stems bearing them die or are killed by fire or drought. In *Banksia*, the follicles are in cone-like, woody infructesences. In the Sydney region, Grevilleoideae with follicles have winged seeds, although seeds of nearly all species of *Grevillea* in the region have, according to Makinson (2000), short, apical wings or, in most of the species, apical elaiosomes, though a few lack even these, for instance *Grevillea caleyi* and *Grevillea longifolia* (see Auld & Denham 1999).

The diversity of fruit and the mode and timing of dispersal of seeds indicate that, in the Sydney region, as in south-western Australia, Proteaceae in infertile sites have a diversity of responses to environmental events and conditions, at least at this phase of the life cycle. Responses of plants across their life cycles to these environmental conditions and events constitute the processes underlying patterns of distribution. It is only through understanding these processes and how they result in survival and reproduction of populations of interbreeding individuals that patterns of distribution and abundance can be interpreted and predicted. This is not only of scientific interest, but required for managing such populations, particularly, in the context of the Sydney region, in relation to events such as fire.

Ecological processes in Proteaceae of the Sydney region

In the Sydney region, processes affecting survival and reproduction in populations of Proteaceae may be expected to vary both across various types of habitat and within particular habitats. It is convenient to review processes across various phases of life cycles of various Proteaceae in the region, thence how populations are constrained in different ways in them and how various patterns in their distribution and abundance may arise and vary in time and space across the landscape. To survive and reproduce, a plant must acquire resources and grow (Fig. 1).

Growth and resources

Seed reserves

Resources are not only acquired by plants during their growing phase, they are also passed on to them in seed reserves from their maternal parent. After germinating from the seed, resources in short supply to seedlings may include light, inorganic nutrients and water. Water is taken up by seeds from soil; indeed, it is necessary for their germination. Inorganic nutrients are in short supply in heath soils, though there may be an initial flush after fire, as Siddiqi et al. (1976) found, but light is generally abundant for seedlings, particularly after fire. In rainforest, light may be limiting to seedlings, while nutrients in the soil may be sufficient for growth. In alpine areas, due to active weathering of the soil and open conditions, both nutrients and light may be sufficient for seedling growth. In their survey of nutrient reserves in seeds of Proteaceae, Pate et al. (1986) showed that particularly high levels of nitrogen, phosphorus and magnesium are generally in those seeds that had high levels of

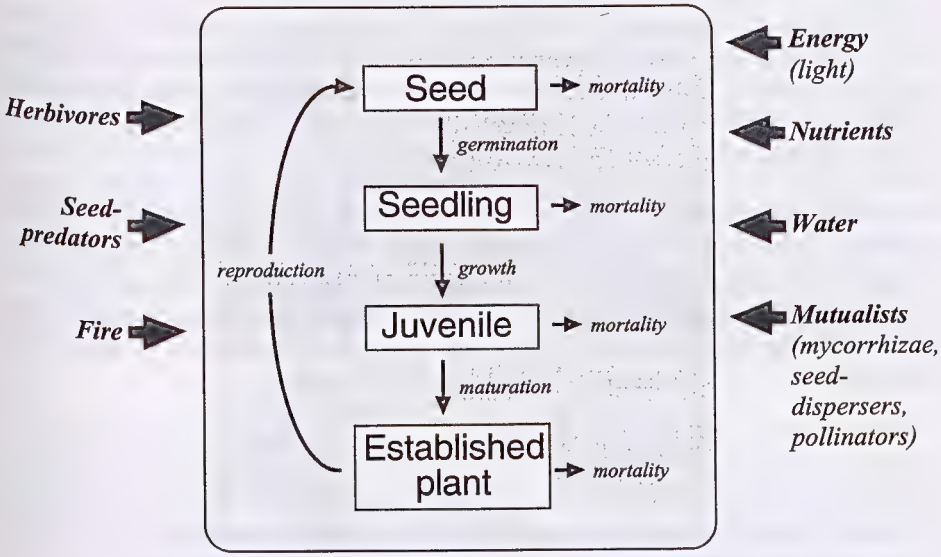

Fig. 1. Diagram indicating processes affecting survival and reproduction across various phases of life cycles of Proteaceae.

protein, and that oil was abundant in seeds of most species with starch being universally absent. Species with relatively low levels of inorganic nutrients included the Tasmanian alpine endemic *Bellendena montana* and rainforest species *Macadamia integrifolia* and the Chilean *Gevuinia avellana*. Embryos of *Macadamia integrifolia* are high in lipid and low in protein, compared to other species of Proteaceae, most of them from infertile soils, in data reviewed by Lamont and Groom (1998). This aligns with the suggestion of Pate et al. (1986) that large energy reserves have high survival value to seedlings under rainforest canopies on fertile soils, where light but not inorganic nutrients may be in short supply.

In the Sydney region, certain trends in seed reserves of Proteaceae may be expected across the range of habitats occupied by them. It may be expected that higher levels of inorganic nutrients occur in the embryos in seeds of species occurring in heaths than in those in rainforest and other fertile sites, and, conversely, that those in rainforest have a higher proportion of their seed reserves as lipid than those occurring elsewhere. It would be instructive to test this expectation within genera. This could be done in *Banksia*, along the range of fertility its species occupy, with *Banksia integrifolia* at the most fertile end with subspecies *monticola* on basalt in montane rainforest and subspecies *integrifolia* on recently deposited dune sands, some of which have significant amounts of shell, and, at the infertile end, *Banksia serrata*, on sandstone ridges and podsolised dunes and *Banksia aemula*, on highly podsolised sands. In the region, three species of *Lomatia* occur over a range of fertility; *Lomatia myricoides* occurs in moist, reasonably fertile sites, while *Lomatia silaifolia* occurs on infertile, dry sandstone soils.

Amongst Proteaceae occurring in infertile sites in the Sydney region, there is opportunity to test the suggestion of Pate et al. (1986) that small-seeded species tend to have higher proportions of inorganic nutrients in embryos than the larger-seeded species. It would be instructive to make such comparisons both within and between species whose fruit is a achene and those in which the fruit is a follicle, as well as between them and species of *Persoonia* which has drupes.

Beyond the Sydney region, it would be interesting to examine the seed reserves of rainforest, alpine and arid-zone Proteaceae, particularly the relative proportions of inorganic nutrients, proteins and lipid in their embryos and to make such studies across and within genera. Studies within *Grevillea* across representative species from various habitats within the wide ecological range of the genus would be particularly interesting.

Acquisition and conservation of resources

Resources that plants acquire during growth are energy from light, carbon dioxide, water and inorganic nutrients. Acquisition of inorganic nutrients and water by Proteaceae from infertile soils and their use in plant growth have received critical attention, particularly under mediterranean climates in Australia [e.g. Specht et al. (1958), Jeschke & Pate (1995) and Pate et al. (1998)]. Acquisition of sufficient light for photosynthesis is unlikely to be a problem for heath plants, particularly in the early phases of growth after fire, but may be critical in seedling growth in Proteaceae in rainforest. This seems to have received not even preliminary study.

Establishment in rainforest

Successful acquisition and use of available light by rainforest seedlings and saplings have to be assessed in relation to dynamics of the canopy above them. Seedlings of some species can survive and grow into the canopy only if there is a large gap above them, others may be able to survive below an intact mature canopy and make signifcant growth when small gaps in the canopy arise above them, while others may survive and make slow growth sufficient to complete their life cycle below an intact canopy. These and other possibilities are identified among species of trees in tropical rainforest by Whitmore (1975) and Swaine and Whitmore (1988), together with some of the events that create gaps in the canopy, including branch and tree falls, damage to the canopy by hail, severe winds, or lightning strikes. Observations are required on where and how seedlings of Proteaceae in Australian rainforest arise and survive and the circumstances that allow them to progress to saplings and beyond to mature reproducing adults. Observations in Appendix 1, p. 164, of Connell et al. (1984) indicate that, in a sample plot in north-eastern Queensland, seedlings of *Cardwellia sublimis*, a *Carnarvonia* species, presumably *Carnarvonia araliifolia* var. *montana* (Hyland 1995), *Darlingia darlingiana* and *Gevuina bleasdalei* became established between 1965 and 1981 under a rainforest canopy that included adults of the same species, as did seedlings of *Orites excelsa* in the same period below a rainforest canopy containing its adults in a plot in Lamington National Park in southern Queensland. In contrast, seedlings of *Grevillea robusta* do not occur below the canopy of their own species and

colonise habitats such as the margins of rainforest, levees of streams in rainforest and areas disturbed by roading or past cultivation (Webb et al. 1967). Clearly, to gain understanding of populations of rainforest species of Proteaceae, studies are required of their seed dispersal, germination, survival and growth of seedlings and saplings in relation to dynamics of light mediated by the canopy above them. This includes species in the family in and around rainforests in the Sydney region. Is *Helicia glabriflora* a gap- or a shade-regenerator; does it require a gap in the canopy for ongoing growth? Are *Banksia integrifolia*, *Lomatia myricoides* and *Stenocarpus salignus* species of the well-lit edges of rainforests with which they are associated? For establishment of seedlings and their onward growth, are large, relatively long-lasting gaps required, such as might arise by fire at the edge of rainforest?

Proteoid roots and nutrient uptake

In the Sydney region, soils that are less fertile than those that normally support rainforest are widespread. In these soils, as Beadle (1954, 1962, 1966, 1968) showed, inorganic nutrients, especially phosphorus, are normally in short supply, particularly in heath and scrub on podsolised sands and sandstone. Proteoid roots, possessed by all Proteaceae except the Persoonioideae, *Symphionema* and *Agastachys*, are regarded as being important in the uptake of inorganic nutrients (Purnell 1960, Jeffrey 1967, Lamont 1972a & b, 1981, 1982, 1984, Malajczuk & Bowen 1974, Pate 1994, Jeschke & Pate 1995, Pate et al. 1998), a view supported by data from three *Banksia* species from heathland in the Sydney region (Siddiqi & Carolin 1976). Observations of Grierson and Attiwill (1989) suggested that the proteoid root mat of *Banksia integrifolia* enhances uptake of nutrients by chemically modifying the soil environment. In artificial media, the production of proteoid roots in seedlings of *Telopea speciosissima* was found to vary with level of phosphate supplied (Grose 1989), and in those of *Banksia ericifolia* with levels of phosphate and iron supplied (Handreck 1991). In the mediterraean climate of south-western Australia, the production and activity of proteoid roots are limited to the wet season (Lamont 1976, Pate et al. 1998). Whether the production and activity of proteoid roots are seasonal in the Sydney region is yet to be assessed, though, since the climate is not nearly so predictably seasonal, such seasonal production and activity are not likely.

Once acquired, inorganic nutrients, especially phosphorus, are sparingly used and highly conserved in the growth of Proteaceae on infertile soils. One manifestation of this is the production of sclerophyllous leaves (Beadle 1954, 1962, 1966, 1968, Loveless 1961). Over the range of soil fertility that Proteaceae occupy in the Sydney region, and more generally in eastern Australia, it could be expected that leaves from fertile sites would have more phosphorus per unit weight and would be less lignified and generally have less hardened tissue than leaves of plants from infertile sites. Whether this is so requires testing both in the Sydney region, and more generally in eastern Australia, across taxa within the family and also within those genera, such as *Banksia* in the Sydney region and *Grevillea* in eastern Australia, whose species are distributed over a wide range of soil fertility.

As already noted, seeds of Proteaceae tend to be lavishly provisioned with resources that seedlings establishing in their habitat will find scarce. Resources of inorganic nutrients available from the maternal parent for provisioning seed may limit seed set in some Proteaceae from infertile soils (Stock et al. 1989, Lamont & Groom 1998); this should be considered with other factors controlling seed set in these plants (Ayre & Whelan 1989). Are Proteaceae on infertile soils in the Sydney region limited in their seed set by resources available in the maternal plant? This was certainly inferred to be so in a population of *Banksia ericifolia* in the Sydney region from studies of pollination by Paton & Turner (1985), and was raised as a possibility in *Banksia spinulosa* in Victoria by Wallace and O'Dowd (1989) who found that fruit set per infructescence was increased after applying both insecticide and inorganic nutrients.

Questions for research:

1. Are the proportions of inorganic nutrients in embryos in seeds of Proteaceae inversely related to fertility of sites and is their lipid content inversely related to availability of light for seedlings in the sites?
2. In infertile sites, is the proportion of inorganic nutrients in embryos in seeds of Proteaceae inversely related to seed size?
3. In Australia, are the proportions of various forms of seed reserves in the Proteaceae related to habitat?
4. In the Sydney region, and in eastern Australia generally, under what range of light conditions do seedlings of various species of rainforest Proteaceae arise, survive and grow to maturity?
5. Do the Persoonioideae, *Symphionema* and *Agastachys* (Proteoideae) have systems of uptake of soil nutrients that are as effective as those of the proteoid roots of other Proteaceae?
6. Are the production and activity of proteoid roots seasonal?
7. Does phosphorus per unit dry mass of leaf show a positive relationship, and does degree of sclerophylly, measured as specific leaf area, show an inverse relationship to fertility of site, in Proteaceae of the Sydney region and, more generally, in eastern Australia?
8. Is resource limitation a major factor in controlling seed set in Proteaceae on infertile soils?

Decomposition of litter

It is expected that rates of decomposition of litter will be faster under fertile than infertile conditions along gradients of soil fertility that exist in the Sydney region and elsewhere in eastern Australia. This could be tested for litter of plants of Proteaceae in the Sydney region from rainforest to heath sites.

Preliminary data of Specht and Rayson (1957) from South Australia indicate that, in Dark Island Heath, leaves shed by *Banksia marginata* and *Banksia ornata* take between 18 and 30 months to be completely decomposed. Further work by Specht (1981b) confirmed that, in layers of dead leaves deposited under bushes of *Banksia ornata*, the

fallen leaves were almost completely decayed after two years. Specht (1981b) found that leaves falling in summer-autumn showed an initial rapid loss of dry matter up to June, no loss for the next 10 to 12 months, but then, after they were blanketed by newly shed leaves, a steady loss in dry matter until their complete decay. In contrast, phosphorus in the layer of fallen leaves did not begin to disappear until the second summer, but, following the layer's colonisation by fine rootlets, then disappeared rapidly in the final 4 to 6 of the 30 months of observations.

Questions for research:

1. Does the rate of decomposition of litter of plants of Proteaceae vary with soil fertility?
2. Are particular sets of micro-organisms involved in decomposition of litter of plants of Proteaceae?

Mycorrhizae and micro-organisms

Although fungi may be associated with roots of many Proteaceae, no symbiotic mycorrhizae appear to be formed in Proteaceae with proteoid roots. Malajczuk and Bowen (1974) showed that, in seedlings of *Banksia grandis* grown in sterile cultures, the formation of proteoid roots was induced by inoculating the cultures with washings from fresh proteoid roots growing in a nutrient-poor soil. They concluded that micro-organisms were involved in inducing proteoid roots, though, in the absence of a control of an inoculum of sterilised washings, the possible influence of chemical agents in the washings cannot be ruled out. Lamont and McComb (1974) compared seedlings of *Hakea prostrata* grown in autoclaved and non-autoclaved sand, and showed that micro-organisms were probably involved in the formation of proteoid roots, though they could not dismiss the possibility that autoclaving the sand either released nutrients or a substance that inhibited the initiation of proteoid roots. Proteoid roots appear to function in similar ways to mycorrhizae in other plants, increasing the area for absorption of water and inorganic nutrients from the soil (Malajczuk & Bowen 1974, Lamont 1984).

Endophytic fungi occur in Proteaceae of the Sydney region; Macarthur & McGee (MS submitted to *Australian Mycologist*) have isolated eleven unidentified species of fungi from coastal populations of *Banksia integrifolia* from Sydney, the central and northern coasts of New South Wales. Bellgard (1991) observed arbuscular mycorrhizae in roots of *Conospermum longifolium*, *Conospermum taxifolium* and *Telopea speciosissima*, but observed hyphae with vesicles but no arbuscules in roots of *Persoonia levis*, *Persoonia pinifolia*, *Hakea dactyloides*, *Grevillea buxifolia*, *Grevillea oleoides* and *Grevillea sphacelata*, as had McGee (1986) in *Grevillea ilicifolia*. Hyphae, typical of fungi that form arbuscular mycorrhizae, were observed by Pattinson (2000) in roots of seedlings of *Banksia ericifolia* and *Banksia serrata* collected from the field in the Sydney region. In experimentally raised seedlings of *Banksia ericifolia*, he showed that infection of roots by a *Glomus* species resulted in the production of hyphal vesicles but not arbuscles and infected seedlings tended to have less growth than uninfected seedlings. In short, in his work and in other work to date, there is no evidence of a functional symbiosis in mycorrhizae in Proteaceae.

The possibility that bacteria associated with the roots of local Proteaceae may assist in uptake of phosphate from the soil has been raised by the work of Wenzel et al. (1994). They showed that bacteria isolated from the proteoid and non-proteoid lateral roots of field-grown seedlings of *Telopea speciosissima* solubilised calcium phosphates in cultures when nitrogen was supplied as NH_4^+ but not when it was supplied as NO_3^-. Whether the bacteria render insoluble phosphates in soils soluble and make them available for uptake by roots of seedlings in the field is as yet unknown.

Fungal diseases, and some of the fungi causing them, are known among local Proteaceae, particularly among those of horticultural interest such as *Telopea speciosissima*. In *Telopea speciosissima*, the identity of several fungi entering plants through the root in horticultural conditions is known (Summerell et al. 1992), and so is the identity of the fungus causing crown and stem canker (Summerell et al. 1990) and of fungi that are leaf pathogens (Crous et al. 2000). *Phytophthora cinnamoni* has been isolated from Royal National Park (Keith McDougall pers. comm.). In eastern Australia, some Proteaceae (e.g. *Telopea speciosissima*) seem to be susceptible to this pathogen, but not to the same extent as the wide range of susceptible Proteaceae in Western Australia. Leaf spot occurs among wild populations in Proteaceae in the Sydney region, as in *Hakea dactyloides*, but what pathogens are in such populations and whether there are patterns in the association of particular parasitic micro-organisms with Proteaceae in the region are unknown.

Questions for research:

1. Do bacteria associated with roots of Proteaceae assist in uptake of phosphates by the plants?
2. Is the initiation of proteoid roots stimulated by micro-organisms in Proteaceae?
3. What pathogens occur in wild populations of Proteaceae?
4. Do patterns occur in micro-organisms parasitic on Proteaceae in relation to soil fertility?
5. To what extent are eastern Australian Proteaceae susceptible to and infected by *Phytophthora cinnamoni*?

Plant-animal interactions

Animals take food from plants. This is often a tax on the flow of resources to the next plant generation. In Proteaceae, with their relatively lavish investment of protein, phosphate and lipid in seed resources, the most serious and potentially damaging form of herbivory is eating of seeds. Least damaging is the taking of nectar, particularly in nutrient-poor habitats where light is often abundant and plants, though poorly supplied with inorganic nutrients, have abundant energy to expend in surplus carbohydrate. It is perhaps not surprising that the most spectacular floral displays with heavy flows of often concentrated nectar are among Proteaceae on infertile soils, both in Australia and in southern Africa.

Herbivory

Leaves and stems of Proteaceae are attacked by insects of various sorts and in various ways (CSIRO 1991). Proteaceae of the Sydney region rarely display extensive insect damage, such as seen occasionally in the almost complete defoliation of some eucalypts. Such defoliation is hardly to be expected in plants most of which are highly sclerophyllous and in a family many of whose taxa contain poisons (Swenson et al. 1989, CSIRO 1995). Cyanogenic glycosides occur in several species, including *Xylomelum pyriforme*, while positive tests for cyanide have been obtained in young leaves of *Hakea dactyloides*, flowers of *Hakea saligna*, parts of flowers and fruits of *Lomatia silaifolia*, and in *Lambertia formosa* (based on the Everist's (1974) summary of the work of various authors). In *Grevillea macleayana* (previously *Grevillea barklyana*), Edwards (1990) also got positive tests for cyanide in about 25% of seed coats obtained following germination of soil-stored seed.

Significant leaf damage is sometimes evident, as in *Banksia oblongifolia*, perhaps less so in leaf canopies formed during the first year after fire than in the leaves two or more years after fire (P.J.M. pers. obs. Myall Lakes). Zammit (1988) recorded damage in *Banksia oblongifolia* by stem-boring insects of a few shoots among those regrown 18 months after fire. Whether there are spatial or temporal patterns to be found in insect damage of vegetative parts of Proteaceae in the region, or whether such damage is critical in controlling either the distribution or abundance of any Proteaceae in the region, is currently unknown. Vertebrate damage of vegetative parts of Proteaceae in the region appears to be even less common than damage by insects, though in young shoots of *Petrophile pulchella* some appear to have been bitten off by mammalian incisors, while Zammit (1988) suspected Swamp Wallabies (*Wallabia bicolor*) of grazing young shoots of *Banksia oblongifolia*.

Inflorescences and infructescences of Proteaceae may be attacked by animals. For instance, in *Lomatia silaifolia*, flowering and fruiting branches were heavily browsed, with 69% of exposed branches of inflorescences destroyed, probably by Swamp Wallabies (*Wallabia bicolor*) (Denham & Whelan 2000). In species of *Banksia*, inflorescences and infructescences are attacked by insects (Scott 1982) and infructescences by cockatoos as they search for insects within them (Scott & Black 1981, Witkowski et al. 1991). Zammit and Hood (1986) showed that insecticide treatment of inflorescences of *Banksia ericifolia* from before anthesis through to flowering and on to maturation of fruits decreased the number of barren infructescences, prevented damage of the rachis by boring insects and, in fertile infructescences, prevented damage of seeds and increased the number of seeds matured. In *Banksia spinulosa*, Wallace and O'Dowd (1989) found that the number of follicles per inflorescence was increased when both insecticide and additional inorganic nutrients were applied to the shrubs, while, in *Banksia spinulosa* var. *neoanglica*, Vaughton (1990a) showed that application of insecticide increased number of seeds produced per inflorescence and per plant.

Seed predation

Losses of seed from the follicles before dispersal, due to predation by insects, was shown by Zammit and Westoby (1988) to be 20–30% in populations of *Banksia oblongifolia* and *Banksia ericifolia*, though in one population of *Banksia ericifolia* there were no such losses. Similar levels of predation were found in *Banksia ericifolia*, *Banksia serrata* and *Petrophile pulchella* by Bradstock (1985) though he measured much higher levels of predation (e.g. > 50%) in old (> 5years old) compared with young (circa 5 % — one year old) cones. Auld and Scott (1997) found that in populations of *Grevillea caleyi*, 20–31%, and in a population of *Grevillea shiressii*, 57% of seeds were lost before dispersal. In *Grevillea shiressii*, significant losses of seeds were to a wasp, *Eurytoma* sp., and in *Grevillea caleyi* to a weevil, *Cydmaea dorsalis* (Auld & Scott 1997). Weevils of this species also feed on seeds of *Grevillea buxifolia*, *Grevillea linearifolia*, *Grevillea sericea* and *Grevillea speciosa* (Auld et al. 1993). French (unpublished data) found a diversity of levels of predation of seeds of *Grevillea* species before dispersal. Only 4% of seeds were lost in *Grevillea oleoides*, but between 40 to 50% of seeds were taken in *Grevillea sphacelata*, *Grevillea linearifolia* and *Grevillea mucronulata*. Vertebrates and invertebrates took seeds, and levels of predation varied spatially and temporally. Auld and Denham (in press a) found that larvae of *Cydmaea* were the major consumers of seeds before dispersal in *Grevillea caleyi* and *Grevillea buxifolia*, while, in smaller-seeded species *Grevillea shiressii* and *Grevillea linearifolia*, the wasp *Eurytoma* sp. was the major consumer. In their survey of five species of *Grevillea*, Auld and Denham (in press a) found that, although pre-dispersal losses of seed were appreciable, they were not as high as post-dispersal losses, with the exception of *Grevillea shiressii*, where they observed the highest loss of developing seeds (46%). Parrots take immature seeds from follicles of *Grevillea* spp. In populations of *Grevillea macleayana*, Vaughton (1998) showed that 9–40% seeds are taken before dispersal by Crimson Rosellas (*Platycercus elegans*), while Eastern Rosellas (*Platycerus eximius*) fed heavily on seeds in follicles of garden-grown *Grevillea caleyi* (P.J.M. pers. obs.). In *Grevillea macleayana*, there was loss of seeds before dispersal to insects but this was not as great as that to parrots (Vaughton 1998).

Seeds may be attacked by animals after dispersing from their parental fruits. In populations of *Grevillea caleyi*, *Grevillea longifolia* and in a population of *Grevillea shiressii*, 82–92%, 92–93% and 60% of dispersed seeds were lost to predation by animals (Auld & Scott 1997). In populations of *Grevillea macleayana*, 78–100% of dispersed seeds were taken (Vaughton 1998). In these species, most of the seeds lying on the soil are consumed by mammals, in *Grevillea macleayana* by rodents (Vaughton 1998) and in the *Grevillea* species studied by Auld and Scott (1997) and by Auld and Denham (1999) by Swamp Wallabies (*Wallabia bicolor*) and Bush Rats (*Rattus fuscipes*). In *Grevillea caleyi*, Auld and Denham (in press b) observed that, in the first two fruiting seasons after a wildfire, virtually all seeds dispersed (99–100%) were lost to rats and wallabies, exceeding estimated losses before the fire and those in a population not burnt for ten years.

A consequence of bradyspory in the Proteaceae is that large numbers of seeds are typically released en masse soon after a fire. It is possible that the rate of post-dispersal seed predation will be lowest at this time, if granivores have been temporarily

eliminated by the fire or if they are satiated by the mass of seeds released at one time. O'Dowd and Gill (1984) showed that predation by ants of *Eucalyptus* seeds was least in the couple of weeks immediately after fire. In a manipulative experiment involving a chronosequence of stands of *Hakea teretifolia* of differing age, Turner (1990) found that high proportions of seeds placed on the soil surface (> 50%) were consumed or damaged in uncaged treatments in coastal stands that had been unburnt for more than 10 years. In stands that had burned less than 10 years previously, levels of predation of unenclosed seeds were relatively low (< 20 %). Turner (1990) found a similar pattern in populations in the upper Blue Mountains, but in that case high levels of predation were restricted to sites of longer time since fire (> 20 years). In *Banksia ericifolia*, *Banksia serrata*, *Isopogon anemonifolius* and *Petrophile pulchella*, Bradstock (1991) reported almost total destruction of early germinants from seeds placed in experimental meshed and unmeshed enclosures in an unburnt area, whereas no losses were recorded in a burnt area. In both studies, small vertebrates (probably rodents) were considered as being responsible for these effects, based on patterns of damage to seeds and other circumstantal evidence. Post-fire predation of seeds and seedlings of other bradysporous Proteaceae species requires investigation in the Sydney region. If post-dispersal predation is significant, then factors which affect the predators will determine seed losses. Area or patchiness of the fire is one potentially important factor which needs to be tested (see Whelan 1995).

Whether losses of seed by animal predation both before and after dispersal are critical in overall dynamics of populations was assessed in populations of *Grevillea caleyi* (Auld et al. 1993, Auld 1995, Auld & Scott 1997, Auld & Denham in press b), *Grevillea longifolia* and *Grevillea shiressii* (Auld et al. 1993, Auld & Scott 1997), *Grevillea speciosa* (Auld 1995) and *Grevillea macleayana* (Vaughton 1998). It can be concluded that post-dispersal predation of seeds might be particularly critical in survival of populations under particular regimes of fire. In *Grevillea caleyi*, Auld and Denham (in press b) suggested that, due to the very high losses of seeds to rats and wallabies, particularly in the first two fruiting seasons, relatively long inter-fire intervals, at least three times the juvenile period of the plant, are required to ensure survival of populations. Clearly, similar analyses of seed predation are required in assessing survival of populations of other Proteaceae in the Sydney region.

Floral visitors and pollination

Flowers of Proteaceae in the Sydney region are visited by animals, and all available evidence indicates that they are effectively pollinated by animals, though, for most species, the identities of their specific pollinators are currently unknown.

All the region's Proteaceae have hermaphrodite flowers, though in the inflorescences of some there may be some male flowers, lacking functional ovaries ['andromonoecy' — Goldingay & Carthew (1998)]. Ladd & Connell (1994) reported clear andromonoecy in both *Stirlingia* and *Xylomelum* in Western Australia. In the hermaphrodite flowers, the stigma appears to become receptive after the pollen is shed. It is not clear whether this is an invariable rule (see Goldingay 2000) or how it contributes to the breeding system, for instance in inflorescences in which some flowers are in the male phase while other adjacent flowers are in the female phase.

Pollen is presented in three ways in flowers of the region's Proteaceae. The first, in *Persoonia*, is directly from the dehisced anthers; flowers of *Persoonia* are predominantly visited by insects, some colletid bees foraging only on flowers of *Persoonia* (Michener & Houston 1991, Bernhardt & Weston 1996), and insects are probably their effective pollinators in south-western Australia (Collins & Rebelo 1987). The second is in its explosive release from the anthers triggered by probing of the flower, probing insects being dusted in pollen. This occurs through one mechanism in *Symphionema* (Carolin 1961) and through another in *Conospermum* (Carolin 1961, Morrison et al. 1994). In flowers of *Conospermum*, the explosion of pollen can be released by touching the triggers with a straw (Holm 1978). Collins and Rebelo (1987) suggested that insects are the effective pollinators in *Conospermum* in south-western Australia. *Leioproctus* bees forage on *Conospermum* in south-western Australia (Houston 1989). The third way in which pollen is presented in flowers of the region's Proteaceae is on a specialised area of the style, the pollen presenter, on which pollen is deposited from the anthers before the flower opens. In *Isopogon* and *Petrophile*, the pollen presenter is a region around the style below its top; the pollen deposited thus on the sides of the style would seem to be easily removed by insects of appropriate form, size and behaviour as they probe the flowers for nectar. In south-western Australia, Collins and Rebelo (1987) suggested that *Isopogon* and *Petrophile* are pollinated by insects. The identity of insects visiting and acting as effective pollinators of species of *Isopogon* and *Petrophile* awaits research in the Sydney region. In the region's genera of the subfamily Grevilleoidae, the pollen presenter is at the tip of the style which is thickened in most genera, though, in *Lambertia*, the tip is not thickened and the pollen is presented subapically on the sides of the style. Several of the region's Gevilleoidae have robust flowers, many of them in showy inflorescences with copious nectar, that are visited by vertebrates as well as by insects. Thus, in the region's Proteaceae, floral visitors, and probably effective pollinators, are in part related to subfamilies; flowers of *Persoonia*, sole presentative of the Persoonioidae in the region being visited by insects, those of the region's Proteoidae, *Symphionema*, *Conospermum*, *Isopogon* and *Petrophile*, also by insects; while those of its Grevilleoidae are visited by vertebrates and/or insects — for instance, flowers of *Grevillea sphacelata* are visited by insects while those of *Grevillea mucronulata* are visited by birds and honeybees (Richardson et al. 2000).

A fourth form of pollen presentation has been described by McFarland (1985) and Ramsey (1988). In some *Banksia* species, florets appear to remain closed for some time after they have matured and anthesis has resulted in the deposition of pollen on the pollen presenter. Contact by a large flower visitor is sufficient to trigger flower opening and expose the style tip, but contact by insects is not. Ramsey (1988) suggested that this may be an adaptation which minimises pollen theft by non-pollinating insects such as staphylinid beetles. It may also provide some protection against pollen theft by honeybees; this is worth further investigation. Stimulated floret-opening occurs in some of the straight-styled *Banksia* species of the Sydney region, such as *Banksia integrifolia*, *Banksia paludosa*, *Banksia oblongifolia*, *Banksia serrata* and *Banksia robur*, but not in the hooked-styled species such as *Banksia ericifolia* and *Banksia spinulosa* (R.J.W. pers. obs.).

Most of the work on pollinators and pollination of Proteaceae in the Sydney region has been done in the subfamily Grevilleoidae, much of it in *Banksia*, mostly in heath or sclerophyll woodland. Outside the Grevilleoidae, Krauss (1994a) looked at aspects of pollination in the *Persoonia mollis* complex, Bernhardt and Weston (1996) in several species of *Persoonia*, and Morrison et al. (1994) touched on pollination in four species of *Conospermum*. Within the Grevilleoidae, some genera, *Helicia*, *Lomatia* and *Xylomelum*, would seem to have inflorescences and flowers more likely to be visited and effectively pollinated by insects than by vertebrates; Denham and Whelan (2000) observed only insects visiting inflorescences of *Lomatia silaifolia*. Other genera in the Grevilleoidae, *Banksia*, *Lambertia* and *Telopea*, have robust, showy inflorescences and flowers, often with copious nectar, and forms and shapes suitable to visits by vertebrates. It is, however, only within *Stenocarpus* and the two closely related, species-rich, genera of *Grevillea* and *Hakea* that some species are almost certainly predominantly insect-pollinated while others have inflorescences and flowers suitable to visits by vertebrates. Vertebrates that visit inflorescences of the region's Proteaceae have attracted much research, involving some study of production of nectar and pollen and pollination in *Telopea speciosissima* (Pyke 1981, Whelan & Goldingay 1989, Goldingay et al. 1991a), *Lambertia formosa* (Pyke 1982a, Pyke & O'Connor 1993), *Grevillea speciosa* (Pyke 1983a, 1988, Armstrong 1991), *Grevillea macleayana* (Harriss & Whelan 1993, Vaughton 1996, England et al. in press), *Grevillea mucronulata* (Richardson et al. 2000, Whelan et al. 2000), *Grevillea caleyi* (Whelan et al. 2000), and, above all, in species of *Banksia*.

Mammal visitors

In species of *Banksia* on the eastern coast of Australia, vertebrates that visit inflorescences include flying foxes, *Pteropus alecto*, *Pteropus poliocephalus* and *Pteropus scapulatus*, which visit *Banksia integrifolia* and *Banksia serrata* (Eby 1995), and the common blossom-bat, *Syconycteris australis*, which feeds on both nectar and pollen of *Banksia integrifolia* (Law 1994). The Grey-headed Flying Fox *Pteropus poliocephalus* occurs in the Sydney region, often with high numbers present in summer, as recorded for the Gordon roost (Pallin 2000), but the blossom-bat does not extend as far south as Sydney (Law 1994). Carpenter (1978) suggested that non-flying mammals in visiting species of *Banksia* in the Sydney region might act as pollinators, a suggestion confirmed in the work of Goldingay et al. (1987, 1991a) and Carthew (1993a, 1994), who showed that small marsupials, a dunart, *Antechinus stuartii*, Sugar Glider, *Petaurus breviceps* and Eastern Pygmy-possum, *Cercartetus nanus*, and native rats, *Rattus fuscipes* and *Rattus lutreolus* visit inflorescences of species of *Banksia*, including *Banksia spinulosa*, *Banksia ericifolia*, *Banksia serrata*, *Banksia robur*, *Banksia oblongifolia* and *Banksia integrifolia*, as well as *Telopea speciosissima* (Goldingay et al. 1991a). All these visits by mammals, both flying and non-flying, are nocturnal, but more obvious are the diurnal visits to *Banksia* inflorescences made by honeyeaters (Meliphagidae) and by day-flying insects, including the introduced honeybee.

Bird visitors

Visits of honeyeaters to *Banksia* inflorescences can be readily observed, and it is well known that an important part of the diet of several species of honeyeaters is nectar from *Banksia* and other Grevilleoidae with showy, robust inflorescences. Tongues of honeyeaters, unlike those of nectarivorous birds of other parts of the world, are finely divided into a brush tip, which appears to be particularly well suited to rapid collection of nectar spread over large surface areas as it often is on rachises of *Banksia* inflorescences (Paton & Collins 1989). Whereas in south-western Australia, there is some nectar from species of *Banksia* throughout the year, in eastern Australia, the availability of nectar from *Banksia* is seasonal (see Collins & Rebelo 1987, Copland & Whelan 1989) and the activity of honeyeaters on *Banksia* infloresecences is correspondingly seasonal. As Collins and Rebelo (1987) indicated, in eastern Australia no species of *Banksia* is in flower between September and December, but flowering starts in January when somewhat under 40% of the species of *Banksia* flower and reaches a maximum in April, May and June when 80% are in flower, with successive decreases in July and August. In the Sydney region, in many heaths and sclerophyllous scrubs and woodlands, *Banksia* nectar becomes available from January due to flowering of species such as *Banksia serrata*, *Banksia oblongifolia*, and, in coastal areas, *Banksia integrifolia*, but reaches its maximum availability in April to June when species such as *Banksia marginata*, *Banksia spinulosa* and *Banksia ericifolia* are in flower. In some heaths and scrubs, *Banksia ericifolia* may completely dominate patches of the canopy, and thus be a source of abundant nectar (Recher 1977, Pyke 1988).

Pyke et al. (1993) showed that, in one such heathland, nesting of honeyeaters resident there was mostly during the period in which nectar production reached its peak. In the same area, Armstrong (1991) showed that, although honeyeaters significantly depleted nectar in uncaged inflorescences of *Banksia serrata* and *Banksia aspleniifolia* earlier in the year, later in the year they did not do so in those of *Banksia ericifolia*; he suggested that *Banksia ericifolia* produced far more nectar than the birds could consume. In New England National Park at 1400 m (McFarland 1986a & b), the only consistent source of nectar was from two species of *Banksia*. Nectar from them was unavailable in spring and early summer, but became available in March when *Banksia integrifolia* subsp. *monticola* started to flower and was most plentiful in mid winter, after *Banksia integrifolia* had ceased to flower but when *Banksia spinulosa* var. *neoanglica* was at its peak of nectar production. Numbers of honeyeaters present were closely related to amounts of nectar available, and, though the daily production of nectar occasionally fell below the daily energy requirements of the honeyeaters in the habitat, the overall production of nectar exceeded their energy needs during the time they were in the habitat (McFarland 1986a) and the amounts of their abdominal fat reserves increased (McFarland 1986b). Studies in these two areas, one at low altitude and the other at high altitude, in eastern New South Wales, both demonstrate the importance of the midwinter flow of nectar from *Banksia* species to populations of honeyeaters.

The concentration of flowering of many nectar-rich Proteaceae in winter and spring, and a dearth of nectar at some other times of year, in the Sydney region perhaps explains why no mammals have evolved to be nectar-specialists. This contrasts with

the situation in coastal heaths and woodlands of south-western Australia, where sequential flowering of *Banksia* species occurs throughout the year (see Whelan & Burbidge 1980). These plant communities support populations of honey possum (*Tarsipes rostratus*), which is a nectar-and-pollen specialist.

Pollen and animal diets

Pollen of eastern Australian Proteaceae is sticky and, if contacted, adheres to animals visiting the flowers (see, for instance, Collins & Rebelo 1987). Some insects may collect pollen directly from the pollen-presenting organs of plants, as, for instance, sometimes, worker bees of *Apis mellifera* (Butler 1954), but most insects and other animals visiting flowers of Proteaceae collect firstly nectar and then clean pollen adhering to their bodies. In some, the pollen cleaned off their bodies is collected and forms part of their diet. Pollen may be the chief source of proteins in their diet, as it is in bees, Apoidae, (Michener & Houston 1991), and the blossom-bat *Syconycteris australis* (Law 1992, 1994). In one group of bees, the pollen in their diet appears to be derived solely from Proteaceae, bees of the subgenus *Cladocerapis* of *Leioproctus* (Colletidae) that gather pollen only from *Persoonia* (Michener & Houston 1991). Pollen from Proteaceae is one source of protein in the diet of some small marsupials, *Cercartetus nanus*, *Petaurus breviceps* and *Antechinus stuartii*, and the rat *Rattus fuscipes* (van Tets & Whelan 1997). Though some honeyeaters ingest pollen of Proteaceae (Recher 1977), there is no evidence that that they digest it; indeed, evidence in the New Holland Honeyeater indicated that it was not digested (Paton 1981). It is clear, however, that pollen from Proteaceae is important, and in some cases, absolutely essential in sustaining populations of some animals.

Effective pollination

Transport of pollen from one flower and its deposition on receptive stigmas are two essential steps of pollination. Not all animals visiting flowers of Proteaceae for nectar contact organs bearing exposed pollen, as Richardson et al. (2000) showed for honeybees visiting inflorescences of *Grevillea mucronulata*. Such animals obviously fail as effective pollinators as they do not transport sufficient pollen. Many animals visiting flowers of Proteaceae have been shown to have pollen adhering parts of their bodies with which they would be expected to contact receptive stigmas, but in relatively few cases has it been shown that pollen is deposited from them onto receptive stigmas [see, for instance, Collins & Rebelo (1987)]. Detection of which animals or group of animals may be acting as effective pollinators may be difficult or fairly straightforward. For *Banksia spinulosa* var. *neoanglica*, at 1400 m in New England National Park, the effective pollinators appear to be honeyeaters, chiefly Eastern Spinebills *Acanthorhynchus tenuirostris*, simply because removal of pollen is mostly diurnal and honeyeaters are the only animals visiting the inflorescences, except for insects late in the flowering season (Vaughton 1990b). In a population of *Banksia ericifolia* at Manly-Warringah, pollination was shown to be diurnal (Paton & Turner 1985). Insects, principally *Apis mellifera*, and honeyeaters visited inflorescences, but experiments excluding different groups of visiting animals indicated that, though both groups of animals produced higher fruit set than wholly bagged inflorescences,

honeyeater visits tended to produce greater fruit set than insect visits (Paton & Turner 1985). Nocturnal and diurnal animals were shown by automated photography to visit inflorescences in a population of *Banksia spinulosa* (Carthew 1993a) at the Barren Grounds Nature Reserve. Nocturnal small mammals visiting the inflorescences carried pollen on their fur (Goldingay et al. 1987), and the three species of marsupial among them foraged widely through the *Banksia* population with most of the movements they made between inflorescences being between different plants rather than different inflorescences on the same plant (Carthew 1994). A careful study by Carthew (1993a) of the behaviour of animals visiting inflorescences, the pollen loads they removed and carried, the relative amount of pollination effected by diurnal and nocturnal visitors assessed by observing growth of pollen tubes in styles, indicated that both diurnal and nocturnal visitors were effective pollinators, and that, within each group, the vertebrates, honeyeaters by day, chiefly Eastern Spinebills, and small marsupials by night, were probably more effective pollinators than insects, bees by day and moths by night. These three examples, all from populations of hooked-styled *Banksia* species in eastern Australia, serve to illustrate that, in the Proteaceae, simply because there is particular form of flowers or inflorescences, no single group of animals acts as effective pollinators, nor do effective pollinators remain the same from place to place.

A film called *A Curious and Diverse Flora* was made by Dr Peter Valder for the International Botanical Congress in Sydney in 1981. While this film was designed to be a '... description of flora of Botany Bay as Banks would have seen it', virtually every close-up of a native plant included *Apis mellifera*, the introduced honeybee! The possibility that the introduced honeybee *Apis mellifera* may reduce pollination was suggested by Taylor and Whelan (1988) for *Grevillea X gaudichaudii* and investigated in detail by Vaughton (1996) in *Grevillea macleayana*. Vaughton found that the bees may remove pollen without effecting pollination and may even prevent self-pollination in this species by removing all the pollen from a pollen presenter before the stigma becomes receptive. The extent to which this may reduce seed set in a population will depend on the relative abundance and activity of honeybees and animals that are effective pollinators. Honeybees are certainly active on Proteaceae in the region. The extent to which their activity may reduce seed set and degree of outcrossing in populations of Proteaceae has yet to be established. In *Telopea speciosissima*, Goldingay (2000) found that stigmas were receptive immediately on anthesis, and that removal of self pollen from flowers resulted in lower levels of fruit initiation but no change in fruit maturation, suggesting that self pollen on pollen presenters caused fertilisation but subsequent abortion. Perhaps this explains the vast numbers of flowers — to produce maximal fruit set while tolerating and expunging self pollination.

Pollination may not proceed to the extent of all the receptive stigmas receiving pollen needed to achieve maximum fruit set. The extent to which the degree of pollination may be limiting fruit set has been tested in some populations of Proteaceae in the Sydney region, as has the extent to which out-cross pollen may increase fruit set over selfed pollen. Artificial pollination by hand of supplementary out-cross pollen to open-pollinated inflorescences has produced increased fruit set in some populations,

as it did in *Banksia paludosa* (Whelan & Goldingay 1986), *Banksia spinulosa*, *Banksia ericifolia* (Copland & Whelan 1989), *Banksia aemula* (Dalgleish 1999), and *Telopea speciosissima* (Whelan & Goldingay 1989), but not in others, *Telopea speciosissima* (Pyke 1982b), *Lambertia formosa* (Pyke 1982a), *Banksia ericifolia* (Paton & Turner 1985), and *Banksia spinulosa* (Whelan & Goldingay 1986). As shown in *Telopea speciosissima* and *Banksia ericifolia*, pollen limitation may be evident in some years but not in others (Copland & Whelan 1989, Goldingay 2000). In *Persoonia mollis*, Krauss (1994a) showed that fruit set resulted predominantly from cross pollen, even though most pollen received by stigmas was from their immediate neighbourhood; in an experiment in one population using bagged flowers, Krauss (1994b) found that fruit set was much greater from cross than self pollen. While autogamy occurs readily in *Banksia spinulosa* var. *neoanglica* in New England (Vaughton 1988) and, closer to Sydney, in *Grevillea macleayana* (Harriss & Whelan 1993, Vaughton 1995), cross pollen in populations of *Banksia* studied in the Sydney region results in more fruit set than self pollen; *Banksia spinulosa* and *Banksia paludosa* (Whelan & Goldingay 1986, Goldingay & Whelan 1990), *Banksia ericifolia* (Goldingay et al. 1991b), and *Banksia spinulosa* and *Banksia ericifolia* (Carthew et al. 1996).

While variability in degree of pollination achieved in populations is one component underlying spatial and temporal variation in fruit set, another is variation in production of inflorescences. Copland and Whelan (1989), for example, found that flowering intensities, at peak flowering, of four *Banksia* species in the vicinity of Barren Grounds Nature Reserve varied by nearly an order of magnitude over four years (1983–86 inclusive) of censusing. Mean numbers of inflorescences per plant at peak flowering of *Banksia ericifolia*, for example, ranged from a low of 1.63 in 1986 to a high of 12.43 in 1985, but percent of inflorescences producing fruits was lowest in this year of greatest flowering. Carthew (1993b) found similar variation in flowering and fruit set over three years in a *Banksia spinulosa* population (Fig. 2).

In interaction of animals and plants of Proteaceae in the collection of nectar and pollen and in pollination, some patterns of mutual dependence are beginning to be understood, especially in some populations of *Banksia*. In most of the Proteaceae of the Sydney region, there is, however, little such understanding. This is so in nearly all members of the subfamily Proteoidae, for instance, in *Petrophile* and *Isopogon*, in nearly all Proteaceae associated with more fertile habitats, such as *Helicia glabriflora*, *Stenocarpus salignus*, *Lomatia myricoides*, and in two woody-fruited genera *Hakea* and *Xylomelum*.

Animals and dispersal of fruit and seed

The role of animals in dispersal of fruits and seeds of Proteaceae in the Sydney region is known in only the most preliminary way. Fleshy fruits of *Helicia glabriflora* perhaps form part of the diet of pigeons or fruit bats, and may be dispersed by these animals. The fleshy fruit of *Persoonia pinifolia* are recorded as being taken by Pied Currawong, Satin and Regent Bowerbirds, Olive-backed Oriole and Lewin's Honeyeater (Barker & Vestjens 1990), though to what extent they act as effective agents of dispersal is unknown. In the *Persoonia mollis* complex (Krauss 1994a), wide dispersal of fruits

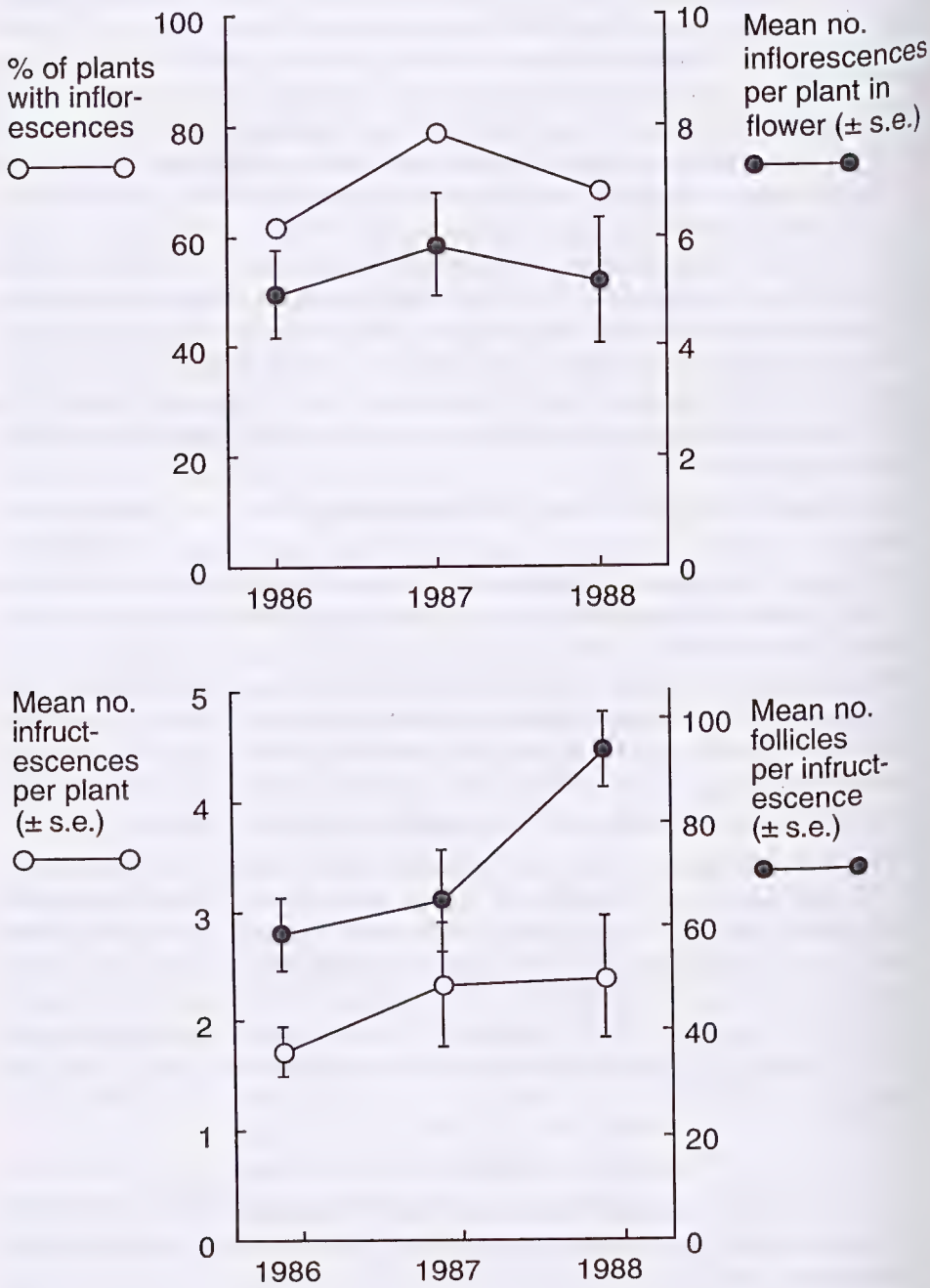

Fig. 2. Variation in flowering and fruit set in a population of *Banksia spinulosa* (data from Carthew 1993b).

followed by establishment of seedlings appears to be very infrequent. Ants are known to take seeds of some Proteaceae, for instance, those of *Grevillea buxifolia*, *Grevillea speciosa* and *Grevillea sericea* (Rice & Westoby 1981). There is an attached lipid body (elaiosome) in *Grevillea buxifolia Grevillea speciosa* and *Grevillea linearifolia* (Auld 1995, Auld & Denham 1999), and in *Grevillea shiressii* (Auld & Scott 1997, Auld & Denham 1999), while *Grevillea caleyi* and *Grevillea longifolia* have no such lipid body and are not dispersed by ants (Auld & Scott 1997, Auld & Denham 1999). Auld and Denham (1999) showed that, while a range of ants were attracted to the elaiosomes of *Grevillea buxifolia Grevillea speciosa* , *Grevillea linearifolia* and *Grevillea shiressii*, smaller ants moved the seeds very little but bit off the elaiosomes, while larger ants, gripping seeds by their elaiosomes, moved them some distance. Though Auld and Denham (1999) did not follow fates of seeds moved, they may be effectively dispersed by larger ants, though larger ants were only involved in 0–24% of seed-ant interactions observed by Auld and Denham (1999) in these species of *Grevillea*. In *Grevillea macleayana*, Edwards and Whelan (1995) found no evidence of dispersal of seeds with no seeds collected from soil cores away from adult plants but with a mean ranging from 4.3 to 15.2 seeds per m^2 estimated from soil cores under canopies.

Questions for research:

1. Do spatial or temporal patterns exist in insect damage of vegetative parts of Proteaceae?
2. Is insect damage of vegetative parts critical in controlling distribution or abundance of any Proteaceae?
3. Is mammalian herbivory on Proteaceae substantial or important?
4. How critical in the dynamics of populations of species of Proteaceae is animal predation on flowers and seeds?
5. Does the area or patchiness of fire affect levels of post-fire predation of seeds and seedlings in bradysporous Proteaceae?
6. What patterns occur in nectar and pollen collection by animals and in pollination in the subfamily Proteoidae, in Proteaceae of relatively fertile habitats, and in the woody-fruited genera *Xylomelum* and *Hakea*?
7. Do activities of *Apis mellifera* alter fruit set and/or extent of out-crossing in populations of Proteaceae?
8. Are animals effective in the dispersal of seeds of Proteaceae, including the rainforest species *Helicia glabriflora*?

Breeding systems and genetic variation in populations

Work on breeding and mating systems of Australian Proteaceae was critically reviewed by Goldingay and Carthew (1998). Their review showed the unevenness of the work done, with much in *Banksia* and much less in other genera. The Sydney region is well represented in the work done, and work in the region has covered a broader range of subfamilies than elsewhere in Australia. In the Sydney region, breeding and mating systems have been investigated not only in the Grevilleoidae, but also in the Persoonioidae in the work of Krauss (1994a & b) in the *Persoonia mollis*

complex, and in the Proteoidae in the work of Morrison et al. (1994) in four closely related species of *Conospermum*.

Breeding systems observed range from from those with no autogamy evident in the *Conospermum* species studied by Morrison et al. (1994) to full self-compatibility in *Grevillea macleayana* without a higher rate of abortion of self than cross fruit (Harriss & Whelan 1993, Vaughton 1995). In *Banksia spinulosa* var. *neoanglica* in New England, a high degree of autogamy occurs (Vaughton 1988), but there are higher rates of fruit abortion in self than in cross-pollinated inflorescences (Vaughton & Carthew 1993). In other species of Proteaceae studied in the Sydney region, it appears that, though self-fertilisation is possible, there are effectively high levels of outcrossing; *Banksia ericifolia* (Paton & Turner 1985, Goldingay et al. 1991b, Carthew et al. 1996), *Banksia paludosa* (Goldingay & Whelan 1990), *Banksia spinulosa* var. *spinulosa* (Goldingay & Whelan 1990, Carthew et al. 1996), *Persoonia mollis* (Krauss 1994b), *Telopea speciosissima* (Whelan & Goldingay 1989, Goldingay & Whelan 1993), *Lomatia silaifolia* (Denham & Whelan 2000), *Grevillea linearifolia*, *Grevillea longifolia*, *Grevillea mucronulata*, *Grevillea oleoides* and *Grevillea sphacelata* (Hermanutz et al. 1998). In the species of *Grevillea* investigated by Hermanutz et al. (1998), there are degrees of self-compatibility with *Grevillea linearifolia* almost completely self-incompatible and *Grevillea longifolia* fairly highly self-compatible. Interestingly, variation also occurs within species. Hermanutz et al. (1998) found that *Grevillea oleoides* was highly self-compatible in one population but more self-incompatible in another. Ayre et al. (1994) found high levels of outcrossing in one population of *Grevillea macleayana* in a site at Jervis Bay but very high selfing in three other populations.

In the Sydney region, and indeed elsewhere in Australia [see Goldingay & Carthew (1998)], breeding and mating systems in Proteaceae have mainly been studied in species from relatively infertile, fire-prone habitats. It would be interesting to know to what extent similar patterns occur in breeding and mating systems of Proteaceae in more fertile habitats.

Variation within and among populations has been explored in some species of Proteaceae in the Sydney region. In the *Persoonia mollis* complex, this has been studied by Krauss and Johnson (1991) and Krauss (1994a & b, 1996, 1997 & 1998). Among populations, the variation extends across the region and is a mosiac of morphologically distinct allopatric or parapatric populations (Krauss 1996) with nine subspecies recognised in it by Krauss and Johnson (1991). An analysis by Krauss (1998) of allozyme variation among populations is consistent with a recent southerly expansion of the complex. Within populations, variation is maintained by outcrossing (Krauss 1994b), though genetic diversity is lower across the complex than would be expected, with a significant deficit of heterozygotes in 11 loci studied by Krauss (1997). Krauss (1997) suggested that the low genetic diversity of *Persoonia mollis*, a species of fire-sensitive shrubs whose individuals usually only regenerate after fire from seed, may be related to relatively frequent localised extinction and subsequent recolonisation of its populations. If this suggestion is correct and applies generally, then genetic diversity might be expected to differ between those species whose individuals regenerate only from seed after fire (obligate seeders) and those in which

some plants survive through fire and sprout again after it (resprouters). Given the large number of congeneric resprouters and obligate seeders in the Proteaceae of the Sydney region, this would be an appropriate region in which to test this expectation.

Within some species of Proteaceae in the Sydney region, the mode of regeneration after fire varies among populations. There are obligate-seeding populations and resprouting populations in a number of species; *Hakea teretifolia* (Auld & Morrison 1992, Barker et al. 1999), which is obligate-seeding in Bouddi National Park (Siddiqi et al. 1976) and resprouting in Myall Lakes National Park (Myerscough et al. 1995); *Banksia ericifolia*, which resprouts at Governor's Head (Jervis Bay) and is an obligate seeder elsewhere (Ingwersen unpublished data, Whelan 1995); and *Banksia marginata* (George 1981, 1999). The pattern of resprouting in some habitats and obligate-seeding in others may relate to variation between habitats in typical fuel loads (determining fire intensity) and/or intervals between fires. There is potentially opportunity to test this by relating resprouting in these species to fire histories of the habitats in which the two forms of their populations occur. Variation among populations in the degree to which seeds are retained in woody infructescences after they mature (bradyspory) has, in *Banksia serrata*, been related to variation between habitats in intervals between fires, with less bradysporous infructescences tending to be in those habitats where intervals between fires are longer (Whelan et al. 1998).

Within some species of Proteaceae in the Sydney region, variation among populations in growth form appears to be related to their habitats. Auld and Morrison (1992) found that, in *Banksia ericifolia* and *Hakea teretifolia*, populations on coastal headlands had a genetically determined prostrate growth form rather than the more erect form found in more inland habitats. The extent to which genetically determined variation that relates to such physical environmental variation occurs in other species of Proteaceae in the Sydney region is currently unknown.

Hybrids between some species of Proteaceae occur in the Sydney region. In *Persoonia*, interspecific hybrids appear to be quite common (Weston 1995a, Bernhardt & Weston 1996). Hybrids between *Conospermum taxifolium* and *Conospermum ericifolium* and between *Conospermum taxifolium* and *Conospermum ellipticum* (Mackay & Morrison 1989) occur in habitats intermediate between those of the parental species but there is no evidence that they back-cross with them (Morrison et al. 1994). Hybrid swarms between *Banksia oblongifolia* and *Banksia robur* also occur in habitats intermediate between those of the parental species near Kariong in the Gosford area and in O'Hares Creek catchment (Elphinstone 1980, Schibeci 1994). Schibeci (1994) had evidence of more back-crossing in one direction than the other. *Banksia robur* reaches the southern limit of its distribution in the Sydney region where it occurs in swamps in valleys over sandstone (Buchanan 1980, Keith & Myerscough 1993, Keith 1994). Further north, there appear to be fewer obvious hybrids between it and *Banksia oblongifolia*, even though they occur in habitats along similar gradients in relation to water table, as on leached sand ridges in Myall Lakes National Park and in other locations on the north coast (Myerscough & Carolin 1986). *Banksia aemula* also reaches the southern limit of its range in the Sydney region. One of its larger populations in the region on leached sands of Bombi Moors in Bouddi National Park (McRae 1990) shows variation in leaf

characteristics (P.J.M. pers. obs.) that may indicate high genetic diversity within it, and possibly introgression from *Banksia serrata*; this could be tested. The four species of *Banksia* just mentioned are each resprouters, and, following the obverse of Krauss' (1997) argument for an obligate-seeding species, survival of some adults, along with episodic recruitment and subsequent survival of seedlings under various conditions through time, may allow accumulation of a wide range of genotypes, including inter-specific hybrids, over a long period. Using allozyme electrophoresis, Henderson (1991) detected hybrids between obligate-seeding *Banksia ericifolia* and resprouting *Banksia spinulosa* subsp. *spinulosa* at Barren Grounds.

Questions for research:

1. Are patterns in breeding and mating systems of Proteaceae in fertile habitats similar to those that have been observed among species of Proteaceae from relatively infertile, fire-prone habitats?
2. Are species of obligate seeders less genetically diverse than congeneric species of resprouters among Proteaceae of fire-prone habitats?
3. Is variation between obligate-seeding and resprouting populations within some species of Proteaceae in the Sydney region related to variation between their habitats in intervals between fires?
4. Is genecological variation that is readily related to physical environmental variation common among species of Proteaceae in the Sydney region?
5. Do *Banksia robur* and *Banksia aemula* have more surviving interspecific hybrids, *Banksia robur* with *Banksia oblongifolia*, and *Banksia aemula* with *Banksia serrata*, in the Sydney region, where they are at the southern edge of their distribution, than further north?

Seed dormancy, bradyspory & timing of germination

Timing of germination

Timing of germination can enhance survival of seedlings when seeds germinate in periods when resources for establishment and growth are high and when abundances of potential predator and disease organisms are low. In Proteaceae of the Sydney region, it is not obvious what mechanisms may time germination of seeds of those species in more fertile, less fire-prone habitats, but, in many species in fire-prone, infertile habitats, it is apparent that germination is timed in various ways to fall largely within a period of 1–3 years, rather than in later years, after a fire.

In these fire-prone habitats, timing of germination in the region's Proteaceae appears to be controlled in three ways. Firstly, mature, non-dormant seeds may be retained on parental plants in fruits that open and disperse the seeds usually only after the plants have been burnt (bradyspory). Secondly, seeds are shed on maturity, with some seeds at least in a dormant state, onto the soil, and with the dormancy of some of the seeds in the soil subsequently broken by the passage of a fire (dormant soil seed bank). Thirdly, plants that survive fire are stimulated to flower, when they resprout after the fire, produce non-dormant seeds that are shed on maturity (fire-stimulated flowering and seed production).

Fire-stimulated flowering of resprouting plants with subsequent production of non-dormant seeds occurs in *Lomatia silaifolia* (Denham & Whelan 2000) and in *Telopea speciosissima* (Pyke 1983b, Bradstock 1995, Denham & Auld 1999). In each case, seed production appears to reach a maximum in the second summer after fire (Denham & Whelan 2000, Bradstock 1995), and, presumably, then the highest number of seedlings might be expected in the following autumn and winter. This mode of timing of germination seems to be the rarest of the three modes in the region's Proteaceae in fire-prone habitats. It also appears to be rare in other families of dicotyledons, but does occur in *Angophora hispida* (Myrtaceae) (Auld 1987b), though it is common in many species of *Xanthorrhoea* (Gill 1981) and in other monocotyledons [see Table 5 of Keith (1996)].

Seed dormancy

Dormancy of seeds is common among several Proteaceae that flower freely and shed seeds or fruits through the intervals between successive fires in the region's fire-prone habitats. Fruits of *Persoonia*, which are shed at maturity, maintain seeds in a dormant state, which is hard to break artificially and is not well understood (Wrigley & Fagg 1989, Ketelhohn et al. 1996), though seedlings of species of *Persoonia* readily appear after fire [e.g. *Persoonia lanceolata* on podsolised sands in the Myall Lakes area (Myerscough & Skelton pers. obs.)]. The small, one-seeded achenes of *Symphionema* and *Conospermum* shed on maturity would be expected to show some form of dormancy. Although Morrison et al. (1994) apparently obtained seedlings of four species of *Conospermum* in the laboratory from freshly collected seed without any form of treatment, viable seeds of *Conospermum taxifolium* collected by Auld et al (in press) were found to be all dormant. After fire, seedlings of *Conospermum* are evident in some habitats at least, with some aspect of fire presumably having broken dormancy of seeds allowing them to germinate. In three Western Australian species of *Conospermum*, treating achenes with smoke has been shown to enhance germination of seeds: *Conospermum huegellii* (Dixon et al. 1995), *Conospermum incurvum* (Dixon et al. 1995, Roche et al. 1997) and *Conospermum triplinervium* (Roche et al. 1997).

Species of *Grevillea* also shed seeds onto the soil surface as they mature. In many species, seedlings are evident after fire, as in *Grevillea buxifolia* and *Grevillea speciosa* (Auld & Tozer 1995). Auld and Tozer (1995) showed that heat was not involved in breaking the dormancy of seeds of these two species, nor of seeds of *Grevillea caleyi*, *Grevillea linearifolia*, *Grevillea longifolia* and *Grevillea shiressii*. They suggested that some other aspect of fire broke their dormancy. In seeds retrieved from soil under bushes of *Grevillea macleayana*, Edwards and Whelan (1995) showed that heat treatment broke the dormancy of some of them, but simply nicking them with a sharp blade allowed an even greater percentage to germinate. Morris (2000) found that smoke enhanced germination of seed in seven species of *Grevillea* from the Sydney region (cf. Roche et al. (1997) for some Western Australian species of *Grevillea*). He also found that a short exposure of seed to heat alone increased germination in *Grevillea buxifolia*, *Grevillea diffusa*, *Grevillea juniperina* and *Grevillea linearifolia*, but did not increase it in *Grevillea mucronulata*, *Grevillea sericea* or *Grevillea speciosa*. After seeds had been exposed to both heat and smoke, higher germination was found in *Grevillea buxifolia*, *Grevillea diffusa*,

Grevillea juniperina, *Grevillea linearifolia* and *Grevillea speciosa* than when exposed to either separately (Morris 2000). Kenny (1999) did factorial experiments with seeds of *Grevillea sericea* and *Grevillea speciosa*, exposing them to heat briefly and smoke before setting them to germinate with or without charcoal. She showed that smoke accelerated germination, that heat and smoke each increased levels of germination attained in each species and that, in *Grevillea speciosa*, smoke with or without other factors brought about maximum germination observed. In *Grevillea sericea*, smoke and heat were additive in their effects on level of germination attained. Morris et al. (2000) showed that, in *Grevillea linearifolia*, the seed coat controls the dormancy of the seed, its removal allowing complete germination of viable seeds. In contrast, dormancy of seeds of the Western Australian *Grevillea wilsonii* is in part controlled by the embryo as well as the seed coat (Morris et al. 2000). From work so far, it is clear that, in this group of Proteaceae with seeds or fruits whose dormancy in the soil may be broken by fire, much remains to be discovered about the nature of the dormancy and how it is broken by fire, especially in species of *Conospermum*, *Symphionema* and *Persoonia*.

Bradysporous fruits

Bradysporous fruits among Proteaceae of the Sydney region are of two types. Firstly, there are fruits with seeds within woody follicles in some genera of the Grevilleoidae, *Banksia*, *Hakea*, *Lambertia* and *Xylomelum*. Secondly, in *Petrophile* and *Isopogon* of the Proteoidae, the small one-seeded achenes are held between persistent bracts that are tightly clustered in oval or globular heads. After fire, the bracts in the heads of *Petrophile* and *Isopogon* open up releasing the achenes, and, similarly, the woody follicles of *Banksia*, *Hakea*, *Lambertia* and *Xylomelum* open and release their seeds after fire. The seeds of *Banksia*, *Hakea*, *Lambertia* and *Xylomelum* appear to have no dormancy and germinate once available moisture is sufficient, though optimum temperatures for germination may vary among species, as Sonia and Heslehurst (1978) showed in *Banksia integrifolia*, *Banksia aemula* and *Banksia serrata*. Bradstock (1985) and Bradstock and Bedward (1992) found a strong effect of ambient temperature on germination of *Banksia ericifolia*, *Banksia serrata*, *Isopogon anemonifolius* and *Petrophile pulchella*. Diurnal cycles of high temperatures typical of summer conditions imposed secondary dormancy on seeds irrespective of moisture availability, whereas germination levels were maximal under cool conditions typical of winter when moisture was non-limiting. Such effects are broadly similar to those found in other bradysporous species from mediterranean environments in southern Australia (Lamont & Groom 1998).

The degree of bradyspory also varies among and within species of *Banksia* in the Sydney region (e.g. Whelan et al. 1998) as it does in Western Australia (e.g. Cowling & Lamont 1985b). Lamont and Cowling (1984) suggested that in species of Western Australian *Banksia*, the persistence of dead florets is related to bradyspory and that their flaming off in fire assists with heating necessary for opening of follicle after fire. In eastern Australia, *Banksia integrifolia* is hardly bradysporous at all, releasing most seeds as they mature, while bradyspory in *Banksia serrata* varies among populations (Whelan et al. 1998). The release of seeds from follicles in *Banksia* after fire may depend on the season and intensity of the fire (Bradstock & Myerscough 1981) and on wetting and drying cycles in subsequent weather [cf. Cowling & Lamont (1985a) for Western

Australian *Banksia* species]. Dunlop (1996) found, in the laboratory, that effects of cycles of wetting and drying on seed release from bradysporous fruits varied among species of Proteaceae of the Sydney region; being obligatory for seed release in *Banksia ericifolia* and *Banksia marginata*; very important in *Banksia oblongifolia* and *Petrophile pulchella*; and having no effect in *Banksia serrata*, *Hakea teretifolia* and *Isopogon anethifolius*.

Survival of seeds in bradysporous fruits through fire varies among species and is related to the degree of insulation from heat afforded to the seeds in the fruits or infructescences. Bradstock et al. (1994) showed that survival of seeds in follicles subjected to standard regimes of heating was better in the larger-fruited species of *Hakea constablei*, *Hakea gibbosa* and *Hakea propinqua* than in smaller-fruited *Hakea dactyloides*, *Hakea sericea* and *Hakea teretifolia*.

Seed dormancy in bradysporous fruits

Although it is highly probable that there is no seed dormancy amongst bradysporous members of Grevilleoidae, it is possible that some dormancy occurs in the one-seeded achenes among species of *Petrophile* and *Isopogon*. The evidence for such dormancy is currently tenuous. Firstly, it can be argued that, at high fire intensities, the bracts in the heads may not afford sufficient heat insulation to maintain viability in the one-seeded achenes they hold, and, thus, survival of populations through such fires could only be ensured by dormant seeds in the soil. In *Petrophile pulchella*, however, Bradstock (1991) found similar levels of germination in achenes taken from cones burnt in a fire of moderately high intensity and in those from unburnt cones. Secondly, dormancy is perhaps suggested by the low germination Whelan and York (1998) observed from achenes of *Petrophile sessilis* sown in field plots compared from that observed from seeds of *Hakea sericea* in the same experiments. Thirdly, and even more tenuous, is the occurrence of *Petrophile pulchella* on leached sand dunes ridges in the Eurunderee system in Myall Lakes National Park, the only obligate-seeding bradysporous species to occur there [see Appendix II of Myerscough et al. (1995)]. If the frequency of fire there is, during some periods, very high [as hypothesised by Myerscough and Carolin (1986)], then the only means by which such an obligate-seeding bradysporous species would avoid local extinction would be through maintaining some dormant seeds in the soil, or by dispersing large distances. Though Bradstock (1985) found no evidence of dormancy among achenes of *Isopogon anemonifolius* and *Petrophile pulchella*, based on germination in the laboratory of wetted achenes and tetrazolium tests for viable embryos, it is possible that achenes dispersed in the field may develop secondary dormancy in the soil. Whether such dormant seeds of *Isopogon* and *Petrophile* occur in soil requires investigation.

Whether dormancy of seeds exists in Proteaceae that occur in rainforest and other moderately fertile habitats in the Sydney region requires investigation, as do the spatial and temporal patterns of germination of such seeds in the field. Currently, such matters seem to be completely unknown.

Questions for research:

1. What temporal and spatial patterns occur in the germination of seeds of Proteaceae in fertile habitats, and what dormancy mechanisms, if any, do these seeds have?
2. Do species of *Petrophile* and *Isopogon* have dormant seeds in the soil?
3. Do species of *Conospermum* and *Symphionema* have dormant seeds in the soil, and, if so, how is that dormancy broken?
4. How is recruitment from the soil seed bank in species of *Persoonia* triggered?
5. Are some seeds in populations of all *Grevillea* species dormant? Does seed dormancy vary among species of *Grevillea* with fertility or proneness to drought of their habitats? Do triggers in breaking dormancy in the species vary with their habitat?

Seedlings & their establishment

Seedlings can only arise in sites where seeds have lodged after dispersal and in which germination has occurred. In Proteaceae of the Sydney region, little is known about sites to which seeds are dispersed and those from which seedlings successfully establish, and, importantly, how closely related they are. In two species of *Banksia* and two species of *Hakea* in Western Australian fire-prone shrubland, Lamont et al. (1993) found that sites to which most seeds were dispersed were not necessarily those most favourable for establishment of seedlings. In five species of *Banksia*, also in Western Australian fire-prone habitats, Enright and Lamont (1989) showed that seeds that became buried after dispersal survived better and had a higher probability of giving rise to seedlings than those that remain unburied. In the Sydney region, in four species of Proteaceae, Bradstock (1991) found that conditions of the soil surface were important in establishment of seedlings, with differences between the species. In *Banksia ericifolia* and *Banksia serrata*, Bradstock (1991) showed that establishment of seedlings was unaffected by whether the soil surface on which the seeds were placed had been heated or not, or by the nature of surface, whether it was litter, ash or bare, but, in *Petrophile pulchella*, less seedlings became established on litter than on a surface of pure ash, while, in *Isopogon anemonifolius*, more seedlings established on litter or litter with ash than on other surfaces, except on soils whose surface had only been heated lightly, where the nature of the surface had no effect.

These experiments indicate that, at least in several species, there is no requirement for burnt substrates for early seedling establishment. Bradstock (1985) estimated that annual rates of spontaneous leakage of seeds from bradysporous storages in the interval between fires (unburnt conditions) exceeds replacement of parent plants, beyond ten years after fire. A similar conclusion was reached for *Hakea teretifolia* by Turner (1990). Bradstock (1985) observed the existence of cohorts of *Petrophile pulchella* and *Banksia ericifolia* seedlings in long unburnt stands (> 20 years) but short-term mortality of these was high and was circumstantially linked to predation. In combination with experimental evidence (Turner 1990, Bradstock 1991) these observations indicate that predation of seedlings seems to play a major role in constraining successful establishment to the immediate post-fire period in these species. Nonetheless the role of other dynamic factors such as shrub cover in influencing establishment and survival in unburnt conditions requires further work

(see Bradstock 1991). In particular, the fate of seeds beyond postulated senescence in bradysporous obligate seeders within the region remains totally speculative.

Dunlop (1996) tested the effect of microsite on seedling survival in *Banksia ericifolia, Banksia oblongifolia, Banksia serrata, Hakea teretifolia, Petrophile pulchella* and *Allocasuarina littoralis* by planting seedlings of these species and broadcasting their seeds and those of *Isopogon anethifolius* into a recently burned site at Colo Vale. He located all the seedlings, recorded their survival into the second year, and classified the microsite of each seedling. He found that, in contrast to the work of Enright and Lamont (1989), microsite did not explain much of the variation in survival and that aspect and the presence of neighbouring shrubs had a much greater influence on their survival.

Differences in habitat occupied by species of Proteaceae may be related to sites to which seeds are dispersed and sites in which seedlings successfully establish. In the Myall Lakes area, in heath on leached sand, the segregation of habitats between two species of *Banksia*, with *Banksia aemula* in drier habitats on ridges and *Banksia oblongifolia* on slopes in habitats with shallower water tables, was related to patterns in dispersal of seeds and sites available for successful establishment and survival of seedlings (Myerscough et al. 1996, Clarke et al. 1996). After fire, seeds of *Banksia aemula* were not found in control sites on plots studied by Myerscough et al. (1996) on the moister habitats on slopes, but occurred in the drier habitats on ridges, where they tend to lodge in holes made in the loose sand surface by foraging bandicoots; such holes were largely absent in the more consolidated peaty surface on the slopes. Seedlings of *Banksia aemula* were found to establish on slopes if seeds were buried or sown onto artificially disturbed soil surfaces (Clarke et al. 1996). Seeds of *Banksia oblongifolia* were shown to be present after fire in control sites on plots of Myerscough et al. (1996) both on ridges and slopes, and their seedlings occurred in each habitat but did not survive in drier habitats of the ridges. Myerscough et al. (1996) showed that, under glasshouse conditions, the tap roots of seedlings of *Banksia oblongifolia* were shorter than those of *Banksia aemula* when the water table was low. Thus, in these habitats, the data of Myerscough et al. (1996) and Clarke et al. (1996) are consistent with the restriction of *Banksia aemula* to drier habitats being due to lack of sites suitable for dispersed seed to lodge and seedlings to establish in moister habitats on slopes, and with the restriction of *Banksia oblongifolia* to moister sites due to inability of their seedlings to survive in drier habitats in periods when water tables are low. This differs from competition between *Banksia aemula* and *Banksia oblongifolia* invoked by Siddiqi and Carolin (1975) to explain in part the segregation of habitats occupied by these species in heath at Mourawaring Point in Bouddi National Park. The extent to which segregation of habitats between species of Proteaceae in the Sydney region may be related to differences among species in patterns of dispersal and sites in which their seedlings may establish and survive needs investigation.

The abundance of seedlings, and thereafter adults, in populations of Proteaceae may be restricted by availability of seeds. By adding seeds to sites, it is possible to demonstrate whether recruitment of seedlings is limited by the availability of seeds. For instance, in the Myall Lakes area, after fire in heath on leached sand, Myerscough et al. (1996) showed that addition of seed of *Banksia aemula* and *Banksia oblongifolia*.

increased numbers of their seedlings establishing on otherwise untreated sites. It is probable that low availability of seeds restricts the density of seedlings in many populations of Proteaceae in the Sydney Region. Certainly, the availability of seeds is a key component in understanding fluctuations in populations between fires of certain Proteaceae, such as *Banksia ericifolia*, as is discussed below in considering responses of Proteaceae in the Sydney region to fire.

There is an obvious flush of seedlings after fire that is often commented upon and interpreted as adaptive, given that post-fire conditions seem likely to maximise water, nutrient and light availability to seedlings and minimise competition and herbivory. However, Whelan & Tait (1995) found that not all seeds of *Hakea sericea* and *Banksia spinulosa* released immediately after fire germinated immediately, with new seedlings appearing as much as 15 months after fire. Whelan & York (1998) found a similar pattern for *Hakea sericea* and *Petrophile sessilis*. In some sites, the first seedlings did not appear for over six months after fire. These findings show that post-fire germination is related to rainfall events and that, in the Sydney region, there is not strong seasonality of rainfall and, hence, the timing of the first opportunity for germination after fire is quite unpredictable (Bradstock & Bedward 1992). Seeds that have been lying on the ground for many months (at least > 12 months; Whelan & York unpublished data) still germinate readily when conditions are appropriate. Bradstock (1985) found that, in *Banksia serrata*, *Banksia ericifolia*, *Isopogon anemonifolius* and *Petrophile pulchella*, seedlings emerge up to 700 days after fire, though the extent to which this is attributable to delayed germination or to delayed release of seeds is not known.

Questions for research:

1. How do sites for germination and seedling establishment vary across the region's Proteaceae, and how are these sites related to those in which their dispersed seed lodge?
2. To what extent is segregation of habitats between species of Proteaceae related to differences among species in patterns of dispersal and sites in which their seedlings may establish and survive?
3. To what extent, and under what conditions, is seedling establishment limited by the availability of seeds in populations of Proteaceae in the Sydney region?

Fire and responses to it

Fire burns vegetation in the Sydney region. No habitat in the region is immune from it. There is abundant fossil evidence of fires in the past in various types of vegetation, including rainforest (Martin 1996). Though burning is a variable and stochastic process in the region's vegetation, there are some trends in its variation. Vegetation in fertile habitats appears to burn less often and less intensely than that in infertile habitats. This may be due to various factors related to sheltered positions, greater moisture in these habitats, the disposition of litter, stems and leaves, or higher mineral content of plant material. More mineral-rich plant material burns less easily than less mineral-rich, particularly if the mineral-rich material contains appreciable amounts of phosphate (King & Vines 1963, Cheney 1981). Fertile habitats in the Sydney region often occur where ancient rivers have cut through the Hawkesbury Sandstone cap,

exposing more fertile strata below in sheltered, moist sites, though some occur on basalt caps, as at Mount Wilson (Brough et al. 1924, Keith & Benson 1988), exposed on high plateaux.

As already noted, the diversity and abundance of Proteaceae increase from fertile to infertile habitats. Indeed it is only in infertile scrubs and heaths in the region that Proteaceae may completely dominate the canopy. Occasionally, in such habitats in the region, a single species of Proteaceae, *Banksia ericifolia*, may form the entire uppermost canopy, and the density and size of its individuals be such that continued growth only occurs as some individuals die off; that is self-thinning populations form (see Morris & Myerscough 1983, 1988).

It is in the region's infertile habitats, where Proteaceae are both abundant and diverse, that responses of some of their populations to fire have been relatively well studied and are now reasonably well understood. In fertile habitats, however, where populations of Proteaceae are both low in diversity and in abundance, little is known of their responses to fire. For instance, much less is known of the responses to fire of populations of *Helicia glabriflora*, *Stenocarpus salignus* and *Lomatia myricoides* than of those of many other species of Proteaceae in the region.

Among the Proteaceae of infertile habitats in the region, responses to fire are diverse. The outcome of such responses, in terms of elimination or ongoing persistence of populations, varies between species and, to some extent, between populations.

Fire also varies in space and time, and it is convenient to talk of the term 'fire regime' to describe the pattern of fires a habitat has experienced in time to the present. A fire regime has a number of components: intervals between fires (sometimes termed fire frequency, though frequency should not be taken to imply uniform intervals); the nature of the events of the fires themselves (their intensities, relating to amounts of heat released per unit time per unit length of the fire fronts as they traversed the habitat); the seasons in which they occurred; type of fire, surface, including canopy fires, or subsurface, peat or humus fires [for discussion of fire regimes — see Gill (1975), Whelan (1995), Keith (1996), Bond & van Wilgen (1996)]. It is important to emphasise that a habitat's fire regime is an analytical sketch of what it has experienced, its fire history. Though fire regimes can never be precisely predicted for habitats, they can provide useful goals in their management. For instance, Bradstock et al. (1995) define the domain of fire regimes acceptable for conservation in sclerophyll shrublands and woodlands of the Sydney region in which Proteaceae are major components. Conroy (1996) gives ranges in some components of fire regimes experienced in recent times in such vegetation in Ku-ring-gai National Park; frequency 2–25 years; intensity 250–30 000 kW/m; season, any, but strongly biased toward spring and early summer [see also data of McLoughlin (1998)].

The setting of goals in managing plant populations in fire-prone habitats is logical because, although fire regimes can not be predicted, responses of plant populations, with sufficient knowledge, can be. The responses allowing plant survival under particular fire regimes occur over all stages of the life cycle, and vary in the region's Proteaceae. Variation at two stages of the life cycle in particular can be used to classify their responses to fire (Table 2). This classification is based on more general

Table 2. Responses to fire of Proteaceae in fire-prone habitats of the Sydney region.

Regeneration of adults	Seed bank	Diaspore	Taxa
A. Obligate seeders	(i) Soil	(a) Seeds (b) Fleshy fruit (c) Achene	*Grevillea* spp. *Persoonia* spp. *Conospermum* ?*Symphionema*
	(ii) Bradysporous	(a) Achene (b) Seeds	*Petrophile* *Banksia* spp. *Hakea* spp.
B. Resprouters	(i) Non-dormant	(a) Seeds	*Telopea* *Lomatia silaifolia*
	(ii) Soil	(a) Seeds (b) Fleshy fruit (c) Achene	*Grevillea* spp. *Persoonia* spp. ?Symphionema
	(iii) Bradysporous	(a) Achene (b) Seeds	*Isopogon* *Banksia* spp. *Hakea* spp. *Lambertia* *Xylomelum*

classifications of responses of plants to fire (e.g. Gill 1981, Gill & Bradstock 1992, Keith et al. in press a, Whelan et al. in press), but also uses details of seed banks and diaspores, dispersal units, specific to the region's Proteaceae from fire-prone habitats with sclerophyllous vegetation.

The distinction between those populations in which some adults survive fire (resprouters), and those in which all adults are killed by it and thus re-establish only through seed (obligate seeders) is important in understanding responses to particular fire regimes. One component of fire regime, fire intensity, may determine whether a particular population is resprouting (after fires of low intensity) or obligate-seeding (after fires of high intensity) (Morrison 1995, Morrison & Renwick 2000), though some populations may be obligate-seeding even under low intensities, as Morrison (1995) and Morrison and Renwick (2000) found in *Hakea sericea*.

The following sections of this review consider responses of Proteaceae in infertile habitats in the Sydney region according to their characteristics in resprouting and seed storage.

Bradysporous obligate-seeders

Bradysporous obligate-seeding populations with seed stored in the canopy are liable to local extinction (Gill & Bradstock 1995) when intervals between successive fires are less than the 'juvenile period'. This is defined as the time taken for adult plants bearing mature seeds to have grown from those seeds that were shed after the previous fire. The relationship between short interval between fires and absence of species of bradysporous obligate-seeders from otherwise suitable habitat in the Sydney region is known for *Banksia ericifolia* (Siddiqi et al. 1976, Nieuwenhuis 1987, Bradstock & O'Connell 1988, Morrison et al. 1995, Bradstock et al. 1997), *Hakea sericea*

(Nieuwenhuis 1987, Morrison 1995, Morrison et al. 1995, Morrison & Renwick 2000), *Hakea teretifolia* (Siddiqi et al. 1976, Nieuwenhuis 1987, Morrison et al. 1995) and *Petrophile pulchella* (Bradstock & O'Connell 1988, Morrison et al. 1995). Among obligate-seeding populations in bradysporous species, juvenile periods vary between places (Benson 1985) and between soils of differing depths (Bradstock & O'Connell 1988). Notwithstanding such variation, it is clear that once the interval between fires is very short, less than six years, populations of obligate-seeding, bradysporous Proteaceae in shrub/heathlands within the region may be expected to decline (Bradstock et al. 1995, Williams and Bradstock 2000). Extinction may be expected should such a short-interval fire regime persist without interruption. Typical juvenile periods for common species are as follows: *Banksia ericifolia* 6 (Bradstock & O'Connell 1988, Morris & Myerscough 1988) to 7–8 years (Benson 1985), *Hakea teretifolia* 6–7 (Benson 1985) and *Petrophile pulchella* 5 (Bradstock & O'Connell 1988) to 6–9 years (Benson 1985).

Beyond the juvenile period, fires change densities of populations. As Bradstock and O'Connell (1988) showed, in populations of *Banksia ericifolia* and *Petrophile pulchella*, changes that occur in density between one generation of plants and the next depend on the season and intensity of the previous fire, and the time and weather since it. Seed release is maximised by fires of high intensity in late summer or autumn, germination and seedling establishment are maximised by an ensuing wet winter and, beyond the juvenile period, seeds accumulate in the canopy at least until 30 years after the previous fire (Bradstock & O'Connell 1988). Based on observations of populations in the field and rainfall records for the Sydney region, Bradstock & O'Connell (1988) modelled relative changes in densities expected under optimal conditions of the previous fire and ensuing rainfall and under the least favourable conditions that could be expected. Under optimal conditions in populations of both *Banksia ericifolia* and *Petrophile pulchella*, population densities could increase even at the smallest possible interval between fires of 6 years, while under least favourable circumstances Bradstock and O'Connell (1988) predicted a minimum interval of 13 years between fires would be required just for populations to replace themselves at their previous densities.

Bradstock and O'Connell (1988) also considered the possible effects of having very long intervals between fires in populations of *Banksia ericifolia* and *Petrophile pulchella*. Their modelling suggests that, despite senescence of individuals, available seed would be sufficient for replacement of populations for up to 45 years after a fire in *Banksia ericifolia* and 90 years in *Petrophile pulchella*. They pointed out, however, that it is difficult to test these suggestions in heathland and shrublands in the Sydney region, as there is a lack of long-unburnt stands (e.g. > 25 years without fire). Of all groups of Proteaceae in fire-prone habitats of the Sydney region, the ecology of bradysporous obligate-seeders is perhaps the best understood. Yet, even in this group, many aspects of their ecology in relation to fire remain unknown. As already raised, there is the possibility that the achenes of *Petrophile pulchella*, though held in bradysporous infructescences, may also have a proportion that retain some dormancy in the soil. Also, as noted, juvenile periods vary with habitat, and it is possible that, in the Blue Mountains, populations of *Banksia ericifolia*, *Petrophile pulchella* and other

bradysporous obligate-seeders may have slower dynamics (slower growth, rates of maturation and longer juvenile periods) and require longer intervals between fires to persist than on the coast. Conversely, in the South African Cape region, where some of the obligate-seeding bradysporous Proteaceae from the Sydney region are weeds in fynbos, their population dynamics may be faster and their populations may survive under shorter intervals between fires. For instance, in Cape fynbos, Richardson et al. (1992) found that two years was the juvenile period of *Hakea sericea* and of *Hakea gibbosa*, far shorter than juvenile periods recorded for populations of bradysporous obligate-seeders of Proteaceae in fire-prone habitats near the coast in the Sydney region.

Obligate-seeders with soil seed banks

Among the region's Proteaceae in fire-prone habitats, the dynamics of populations of obligate-seeders with soil seed banks are less well known than those of bradysporous obligate-seeders. This can be related to the increased difficulty of studying seed banks in the soil, rather than canopy-held seed banks. Soil seed banks have, nevertheless, been studied in *Grevillea caleyi* (Auld 1994, 1995, Auld & Scott 1997, Auld et al. in press), *Grevillea longifolia* (Auld 1994, 1995, Auld & Scott 1997), *Grevillea speciosa* (Auld 1995, Auld et al in press) and *Grevillea macleayana* (Edwards & Whelan 1995, Vaughton 1998). Longevity of seed in seed banks has been assessed in *Grevillea caleyi* and *Grevillea speciosa*, and in *Conospermum taxifolium*, *Grevillea linearifolia* and *Persoonia pinifolia* (Auld et al. in press). Not assessed, however, are fates of seeds buried at various depths in the soil, especially during the passage of fires of various intensities [cf. study of *Acacia suaveolens* by Auld (1986a & b, 1987a)].

Fates of seeds of *Grevillea* at various depths in soil can not readily assessed in relation to the passage of fires of particular intensities. This is largely because the breaking of dormancy in seeds of most species of *Grevillea* studied to date is related to smoke, and patterns of penetration of dormancy-breaking smoke to seeds in soil is currently unknown. Such an assessment, using the methods of Auld (1986 a & b, 1987a), may be feasible in *Grevillea macleayana* in which heat does appear to break dormancy of seeds (Edwards & Whelan 1995). In the flush of seedlings after a fire, it is possible, by looking at lengths of the portions of their hypocotyls that were buried, to assess the depths of the seeds in the soil from which recruitment of seedlings occurred (Auld 1986b). Recruitment of seedlings after fire from seeds in the soil is readily observed, as reported in *Grevillea caleyi*, *Grevillea longifolia*, *Grevillea buxifolia* and *Grevillea speciosa* by Auld and Tozer (1995) and in *Grevillea macleayana* by Vaughton (1998).

Among the region's Proteaceae in fire-prone habitats, the juvenile period appears to be shorter in obligate-seeders with soil seed banks than in bradysporous obligate-seeders. It ranges from 2–3 years in *Grevillea macleayana* (Vaughton 1998), 2–4 in *Grevillea speciosa* (Benson 1985, Auld 1995), 2.5–5.0 in *Grevillea caleyi* and 3–5 years in *Grevillea longifolia* (Auld 1994, 1995, Auld & Scott 1997), 4 years in *Conospermum taxifolium* and *Grevillea sericea* (Benson 1985), to 8 years in *Grevillea buxifolia* (Benson 1985). Once the plants become reproductive, the size of the seed bank can be expected to rise in the soil. In populations of *Grevillea caleyi*, however, Auld and Denham (in

press b) showed that virtually all seeds shed in the first two reproductive years were taken by rats and wallabies, and that a period approximately 3 times the length of the juvenile period, 8–12 years, is required between successive fires for the seed bank to be sufficient to sustain the populations. In populations of *Grevillea macleayana*, Vaughton (1998) showed that there were more seeds in the soil beneath a population of 16-year-old bushes than beneath younger or older populations. In older populations, she found high proportions of senescent and dead shrubs, no longer producing seed. Auld (1995) modelled variation of abundance of seed in seed banks of *Grevillea caleyi*, *Grevillea longifolia* and *Grevillea speciosa*. Based on observations of reproductive output of adults, losses of seeds pre- and post-dispersal, and seed longevity in the soil, his models indicated an expected peak in abundances of seed in *Grevillea caleyi* and *Grevillea speciosa* at about ten years, and that in *Grevillea longifolia* seed may be held at maximum abundance over a period of 25 to 50 years after the last fire.

In infrequently burnt vegetation, Nieuwenhuis (1987) reported that *Conospermum taxifolium*, *Grevillea speciosa* and *Grevillea buxifolia* were absent whereas they were present in more frequently burned sites, while Morrison et al. (1995) found that *Grevillea sericea* was among a group of obligate-seeders with soil seed banks from several families whose abundance declined in vegetation with time-since-fire. These observations raise questions about longevity of soil seed banks of this group of plants and the minimum and maximum times between fires that can elapse without endangering the continued survival of the populations. As Auld (1994) pointed out, these questions are crucial in understanding management of much fire-prone vegetation, and the population dynamics of these obligate-seeding plants with soil seed banks. In obligate-seeders with soil seedbanks, the type of analysis and modelling that Bradstock and O'Connell (1988) did for populations of two species of bradysporous obligate-seeders are difficult to do, though they should be attempted. Such an attempt would stimulate study of how soil seedbanks function and how effective they may be in sustaining populations both through short and long intervals between fires. Also, in the region's Proteaceae, study of populations of obligate-seeders with soil seed banks should be extended to include species of *Conospermum* and *Persoonia*.

The susceptibility of obligate seeders to frequent or intense fire may be reflected in their distributions. Gill and Bradstock (1995) introduced the notion of a 'fire shadow', which is a part of the landscape in which fire frequency, and perhaps intensity, is typically lower than surrounding areas. There is some evidence that, in the sandstone plateaux of the Sydney region where fire return times have been shorter since European settlement and the modal season of fires has changed (Clark & McLoughlin 1986, McLoughlin 1998), obligate seeders such as *Grevillea rivularis* (Pickup 1999) are restricted to areas such as stream sides because they have experienced less frequent fires, not because of any preference for edaphic or other features of the riverine environment. Similarly, many of the rare *Persoonia* species of the Sydney region, most of which are obligate seeders, appear to occur in greatest numbers near roads and tracks (P. Weston pers. comm.), again perhaps because of the reduced fire frequencies in this part of the landscape.

Non-bradysporous resprouters with non-dormant seed

Resprouters with non-dormant seed and without bradysporous fruit are the smallest group of Proteaceae in fire-prone habitats in the Sydney region, but the group includes *Telopea speciosissima*. In *Telopea speciosissima*, Bradstock (1995) has shown that, in dynamics of populations, seed production, recruitment of seedlings, their survival and growth to maturity are key processes between fires and that, through fires, survival of plants is also critical. Although more data are required, it appears that, in *Telopea speciosissima*, 8–10 years after fire, less than 25% of juveniles in the population are fire-tolerant, and that, for populations to increase in density, intervals between fires of greater than ten years are required (Bradstock 1995).

Flowering in *Telopea speciosissima*, though stimulated by fire, may continue for some years thereafter (Pyke 1983b, Goldingay 2000), but in *Lomatia silaifolia* abundant flowering only occurs in the first or second year after fire (Denham & Whelan 2000). Denham and Auld (1999) followed flowering, seed produced, post-dispersal predation of seed and seedlings recruited in *Telopea speciosissima* after the fires in Royal National Park in January 1994. They showed that seeds were first produced two years and also produced three years and, in diminished abundance, four years after the fire. They found that establishment of seedlings from seed occurred in one site in each of the years, but in a second site, where predation of seed was higher, seedling establishment was much lower and was zero four years after the fire. In *Lomatia silaifolia*, the only other species of the region's Proteaceae currently known to belong to this group, data are required on all aspects of its life cycle, if the model of Bradstock (1995) is to be applied in understanding effects of fire on its populations and in predicting outcomes of various fire regimes and weather in their survival or variation in abundances of plants in them.

Resprouters with soil seed banks

Almost nothing is currently known of the population dynamics of resprouting Proteaceae in the Sydney region with soil seed banks. They comprise some species of *Persoonia* and possibly some species of *Grevillea* (see account below by Benson and McDougall (2000) in *Ecology of Sydney plant species*, Part 7b). In two species, *Persoonia levis* and *Persoonia linearis*, most adults have a fire-resistant trunk with thick, flaky bark through which epicormic shoots emerge after fire. Of all of the five groups of Proteaceae in the region's fire-prone habitats outlined in Table 2, this group still requires the most basic data on how their seed banks are maintained, recruitment of seedlings from seeds, and survival of plants through fires, for populations of even just one species in this group.

Bradysporous resprouters

In contrast to the last group, there are both data and models on population dynamics of some species in bradysporous resprouters from the region's fire-prone habitats. It is generally taken as given that juveniles become fire-tolerant long before they reach reproductive maturity. Zammit and Westoby (1987a) established that juveniles of *Banksia oblongifolia* could survive fire and resprout from a lignotuber before they reproduced sexually. In *Isopogon anemonifolius* and *Banksia serrata*, the work of

Bradstock & Myerscough (1988) identified stages of the life cycle critically affected by fire and assessed survival of populations through various fire regimes. They showed that, if fires occur before newly-established plants are fire-tolerant, populations will be expected to decline. In *Banksia serrata*, the age at which juveniles become fire-tolerant is about six years, while in *Isopogon anemonifolius* it is about 13 years. Short intervals between fires prevent recruitment of juveniles into adults in each species, Thus, despite having adults that resprout (so that populations of these species are buffered from local extinction by a single short interval between fires), they are susceptible to decline under a long-term regime of frequent fires. In *Banksia serrata*, frequent fires may prevent fire-tolerant juveniles from progressing to the adult arborescent form. Under such a regime, each fire kills their aerial stems and maintains them as lignotuberous fire-tolerant juveniles for longer periods than under regimes where at least one interval between fires is long enough to allow them to develop fire-resistant arborescent stems of adults.

In *Isopogon anemonifolius*, the adult shrub is lignotuberous, so, once the juvenile has become fire-tolerant, its progress to maturity does not require a change of form that depends on a long enough interval between fires. Based on observations of accumulation of viable seed in the seed bank between fires, post-fire recruitment of juveniles and survival of various stages of the life cycle through fire, models of Bradstock and Myerscough (1988) indicate that, under a regime of fires at intervals of five years, greater declines would be expected in populations of *Banksia serrata* than in those of *Isopogon anemonifolius*, while, under a regime of fires at intervals of ten years, the converse would be expected, particularly if the intensities of the fires were high.

A more detailed demographic analysis by Bradstock (1990) looked at effects of interactions between fire intensity and intervals between fires on these populations. From the analysis, he predicted that in *Banksia serrata* populations, numbers of plants would decline when intervals between fires of high intensity were less than 9 years, while for fires of low intensity the critical interval was 11–12 years, while, in *I. anemonifolius*, the respective critical intervals were 14 and 16 years. The longer interval between fires of low intensity required for no decline in the populations is related to poorer post-fire release of seeds and recruitment of juveniles than after fires of high intensity. There are two problems related to generalising from these analyses. Firstly, there is the problem of variability in the estimates in data from populations in making predictions. Morrison and Cary (1994) further explored the sensitivity of Bradstock's (1990) model and showed that predictions of population trends in relation to fire regimes were also sensitive to variations in interfire mortality, not originally included in Bradstock's (1990) analysis. Their work reinforces the importance of basing predictions of population trends on robust data for key life history processes. Secondly, as Bradstock (1990) noted and data of Whelan et al. (1998) show, there is considerable variation in the degree of bradyspory and inter-fire recruitment of juveniles between populations of *Banksia serrata*, indicating that care is required in making predictions from observations of the population dynamics of one set of populations in one area to another set in another area. Nevertheless, demographic studies in this group of Proteaceae in the Sydney region have indicated that, in assessing the effects of fire regimes on their populations, not only has survival of resprouting adults through and

between fires to be considered, but also their seed banks, post-fire and/or inter-fire recruitment of seedlings, the length of the fire-intolerant juvenile period and the transition from fire-tolerant juveniles to reproducing adults.

As Bradstock (1990) pointed out, it is not known if all species in this group of bradysporous resprouting Proteaceae in the region respond to fire similarly to the populations he studied. The group includes the localised bird-pollinated *Hakea bakeriana*, *Lambertia formosa* and the tallest-growing Proteaceae of infertile fire-prone habitats in the region, *Xylomelum pyriforme*. As a first step in understanding effects of fire across the species in group, length of the juvenile fire-tender stage could be determined. A second step could be to determine how long fire-tolerant juveniles take to become seed-producing adults, and whether, as in *Banksia serrata*, this period is also dependent on fire regime. In surveying these two stages of the life cycle, it would be possible to test the assumption which seems to be current that, in this group of plants, fire-tolerance in juveniles is always attained before sexual maturity. Testing this assumption would be particularly interesting in resprouting subspecies of those species, such as *Hakea teretifolia*, that have both obligate-seeding and resprouting subspecies.

Comparison of obligate-seeders & resprouters

Resprouters and obligate-seeders have been compared over a number of characteristics across their life cycles. Some generalisations have been tested in Proteaceae of the Sydney region, especially in bradysporous species. A number of differences between them were predicted by Carpenter and Recher (1979). Some of these have been refuted, especially those in systems of pollination and compatibility (see, for instance, Lamont et al. 1998). Predicted differences that appear still tenable are the relative longevity of plants (resprouters greater than obligate-seeders), age to first reproduction (resprouters greater than obligate-seeders) and growth rates of plants (resprouters less than obligate-seeders). Data of Bradstock and Myerscough (1988) indicate that age to first reproduction in the resprouter *Banksia serrata* is at least 20 years, while in the obligate-seeding *Banksia ericifolia* it is about 6 years (Bradstock & O'Connell 1988). Resprouting populations bear seed sooner after fire than obligate-seeding populations, due to the presence of resprouting adults, as Zammit and Westoby (1987a) showed in those of the respouter *Banksia oblongifolia* and the obligate-seeding *Banksia ericifolia*. Though they bore seed later after fire, populations of *Banksia ericifolia*, after ten years, had larger seedbanks than those of *Banksia oblongifolia*, due to faster rate of growth of individuals and greater reproductive output of individuals of comparable size. Furthermore, Zammit and Westoby (1987b) showed that *Banksia oblongifolia* is less bradysporous than *Banksia ericifolia*, releasing seed more readily without the passage of fire, releasing them more readlily after fires of low intensity and releasing them over a shorter period after fire than *Banksia ericifolia*. After fire, partly due to longer period over its seed is released and slower germination from released seed, seedling establishment is held to be less risky in *Banksia ericifolia* than in *Banksia oblongifolia* (Zammit and Westoby 1987b). Work of Bradstock and Bedward (1992), however, indicated that, under varying soil moisture conditions, the resprouter *Banksia serrata* has a greater spread of seed germination and seedling emergence than the obligate-seeding *Banksia ericifolia*, where emergence is more risky, being rapid under conditions of high moisture.

In a survey of 2–4 year old plants recruited from seed in burnt habitats in south-western Australia, Pate et al. (1990) found that rates and patterns of seedling growth differed between resprouters and obligate-seeders. Across a number of families, including the Proteaceae, they found that obligate-seeders had a greater plant dry mass and a more than fourfold greater shoot:root dry-mass ratio than resprouters, and that starch was more concentrated in the roots of resprouters. Similar differences would be expected between resprouters and obligate-seeders among the Proteaceae of the Sydney region. Among woody-fruited Proteaceae of south-western Australia, Lamont and Groom (1998) found that resprouting species tended to have a few large viable seeds per plant while obligate-seeders have many smaller seeds. To what extent this applies to woody-fruited Proteaceae of the Sydney region is unknown, though it seems unlikely that such a generalisation holds in the region. Some preliminary data on seed size are available in the Sydney region for some species of *Banksia* in Hammill et al. (1998) and of *Hakea* in Bradstock et al. (1994). Also, in Proteaceae of the Sydney region, do characteristics differ as much between resprouting and obligate-seeding populations within species that have both types as between resprouting and obligate-seeding species?

Proteaceae & fire-prone landscapes

Populations of Proteaceae have distinctive patterns of distribution across the region's fire-prone landscapes, particularly discernible in heaths (e.g. Siddiqi et al. 1972), other shrublands (e.g. Buchanan 1980) and swamps (e.g. Buchanan 1980, Keith & Myerscough 1993, Keith 1994). Some of these patterns are variations in distribution of populations between habitats, as in the examples just cited. Other patterns occur in time within habitats due to fire effects. For example, Siddiqi et al. (1972) described variation between habitats in heath on leached sand on Mourawaring Point, with heath on better drained areas dominated by *Banksia aemula* while on less well drained areas the canopy was dominated by tall-growing shrubs of *Banksia ericifolia* and *Hakea teretifolia* together with *Allocasuarina distyla*. These tall-growing shrubs are all killed by fire, and Siddiqi et al. (1976) noted that the structure of the vegetation is changed in the immediate post-fire period to a lower-growing canopy, an important component of which is then the resprouting *Banksia oblongifolia*, that, before the fire, was in the understorey beneath the canopy of the tall-growing obligate-seeding shrubs.

In heathland west of Jibbon Hill in Royal National Park, from a sequence of aerial photographs over a period of approximately 50 years, Keith (1995) mapped areas of thicket of these tall-growing obligate-seeding shrubs, and showed large temporal variation in extent of thicket, which was directly related to fires that occurred during the period. Siddiqi et al. (1976) showed that in areas where intervals between fires are less than the juvenile period of the obligate-seeding bradysporous shrubs, vegetation that may have contained them before the last fire now lacks even their seedlings and that the resprouting *Banksia oblongifolia* is left to occupy the canopy without being overtopped by them. Clemens and Franklin (1981) also reported extinction of populations of *Banksia ericifolia* at North Head after a short interval between fires. *Banksia oblongifolia* may thus occupy the canopy of certain heaths in the Sydney region in two ways. It may do so permanently in the absence of taller-growing obligate-seeding shrubs that include *Banksia ericifolia* and *Hakea teretifolia*, or, if they are present

as seedlings after fire, transiently until these seedlings have grown to overtop its resprouting plants.

Coastal heaths that contain *Banksia oblongifolia*, with or without *Banksia ericifolia* and *Hakea teretifolia* according to their fire history, occur both north (Siddiqi et al. 1972, 1976) and south of Sydney (Keith & Bradstock 1994, Keith 1995). Keith and Bradstock (1994) investigated populations of *Banksia oblongifolia* two years after fire in relation to the pre-fire absence or, if they were present, the variation in cover and height of taller-growing, obligate-seeding bradysporous shrubs of *Banksia ericifolia*, *Hakea teretifolia* and *Allocasuarina distyla*. Their study was in sites near Jibbon Beach in Royal National Park. The density of plants of *Banksia oblongifolia* was greatest in sites where a canopy of taller-growing shrubs had been absent and was least where there had been a tall canopy of them. Furthermore, they showed that the number of follicles produced per plant in *Banksia oblongifolia* was greatest where tall-growing shrubs had been absent. The relationship in these heaths between populations of *Banksia oblongifolia* and those of taller-growing bradysporous obligate-seeders is thus a dynamic one dependent on fire regime, particularly intervals between fires. Where intervals between fires are less than their juvenile periods, the bradysporous obligate-seeders are excluded, but, where fire regimes with intervals between fires of 15–20 years obtain for some time and the density of populations of *Banksia ericifolia* is maximised (Bradstock & O'Connell 1988), *Banksia oblongifolia* may be excluded from an area.

Keith and Bradstock (1994) noted an inverse relationship between the presence of a dense overstorey and floristic diversity in this heathland, consistent with earlier broad ranging correlations noted by Specht and Specht (1989). They hypothesised that a dense overstorey of bradysporous shrubs, as promoted by successive intervals between fire of moderate length, would competitively exclude not only understorey shrubs, as noted, but also herbaceous species. Further studies on the effects of overstorey canopies (Tozer & Bradstock in review) have confirmed strong evidence for competitive exclusion of understorey species. Tozer and Bradstock (in review) demonstrated that competitive exclusion of some understorey species (both total exclusion and reductions in density) can occur beneath shrub canopies within a single long-interval between fires (30 years). Their work however indicated that competitive effects are not unilateral, and that a multi-strata hierarchy of effects may lead to some species of low-stature being favoured by the presence of shrub crowns, while others are excluded, and that soil moisture may mediate the outcome of competition.

Should local extinction of either bradysporous obligate-seeding or resprouting woody-fruited Proteaceae occur, it is possible that dispersal of seed after fire from surrounding areas may allow re-establishment of their populations. Hammill et al. (1998) showed that, after fire, the winged seeds released from the woody fruits of *Banksia serrata*, *Banksia ericifolia*, *Banksia marginata*, *Hakea sericea* and *Hakea teretifolia* were dispersed through the air in windy conditions up to 12 m from the fruits, and thence may be blown further along the surface of the ground. The modal distance seeds of *Banksia ericifolia* moved, after being released from 3 m above ground in a 35 km/h wind in a recently burned heathland site, was 10–14 m, but nearly 10% of seeds moved more than 21 m (see Fig. 3.19 of Whelan 1995). Hammill et al. (1998) also

showed that, although post-fire recruitment of seedlings of *Banksia ericifolia* was highest near the source of the seed and decreased log-linearly away from it, some seedlings occurred up to 40 m away.

Given the nature of the demography of shrubs of Proteaceae and emerging knowledge of their competitive interplay with other co-habiting species in shrub/heathlands in the region, it is likely fire regimes will strongly affect floristic composition of these communities. Management of fire regimes is therefore a pivotal conservation issue. While much knowledge described above is based on empirical studies at fine spatial scales, the nature of fire regimes and their ecological effects transcend such local effects. Comprehension of the ultimate outcome of local extinction, dispersal, and recolonisation requires resolution of these processes at the scale of landscapes.

Keith (1995) validated the demographic model for *Banksia ericifolia* of Bradstock and O'Connell (1988) by examining fluxes in overstorey cover in relation to fire regimes for a 50-year period in the Jibbon heath landscape of Royal National Park. His results, derived from analyses of historical aerial photograph sequences and local records of fires, indicate considerable local instability of overstorey cover at any point within the landscape, within the range of the fire regimes that occurred. Nonetheless, the canopy-dominant obligate-seeders such as *Banksia ericifolia, Hakea teretifolia* and *Allocasuarina distyla* persist to the present. A question that arises is whether such species can be eliminated both 'locally' (point-scale) and 'globally'. What range of fire regimes would be required to achieve such an effect? Bradstock et al. (1996) explored this question using a spatially-explicit simulation model, encapsulating the key life history processes of bradysporous, obligate-seeder shrubs summarised above. Importantly, their model was scaled to account for the relatively short-range dispersal typical of these species, as reported by Hammill et al. (1998). The results indicated that extinction probability (landscape scale) was related to both the size and frequency of fires; low risk of extinction occurred when fires were relatively large and of moderate frequency, relative to the life-span of the species. This somewhat counter-intuitive result, indicated that patchiness of fire cannot be relied upon per se in management to ensure persistence of species.

Such models indicate that the additive effect of patterns and sizes of individual fires must be understood in order to determine the statistical distribution of fire regime components (e.g. fire frequency and intensity) and the resultant probability of persistence of species. Contemporary theory linking analytical life-history and fire-recurrence models (Clark 1991, Bond & van Wilgen 1996) offers a promising avenue for understanding the way that statistical properties of fire regimes may relate to the persistence of both obligate seeders and resprouters in landscapes. The Proteaceae of the Sydney region offer great potential for testing such theory. For example, mixtures of bradysporous, obligate seeder species tend to be uncommon at a fine-scale. Typically patches dominated largely by a single species (e.g. *Banksia ericifolia, Petrophile pulchella* or *Hakea teretifolia)* occur in shrub/heathlands and the understorey of woodlands. Do such patterns of local dominance reflect stochastic sorting of species in the post-fire 'regeneration niche' (e.g. Lamont & Groom 1998), or micro edaphic effects on establishment (Bradstock 1991) or wider but subtle demographic differences? A

possible wild-card could be hitherto unconsidered interspecific effects, such as evidence that fires in dense shrub crowns (e.g. *Banksia ericifolia* thickets) may be lethal for the seedbanks of potential co-habitants such as the small-fruited *Hakea teretifolia* (Bradstock et al. 1994).

A key question that arises from consideration of landscape-level dynamics in species of Proteaceae, is the degree to which differing fire management actions (e.g. suppression of wildfires, prescribed burning) may affect the distribution of fire regimes in a landscape and hence probability of species persistence. Bradstock et al. (1998) extended their earlier modelling approach to consider this problem for several functional groups of woody plants (bradysporous obligate seeders and respouters, plus obligate seeders with soil storages of seeds). Their analyses indicated that trends in population size and extinction probability ('global') were affected by rates of both prescribed and unplanned ignitions. Population decline and high risk of extinction were both positively related to ignition rate from either source (and their interaction) though the nature of such responses was non-linear. High levels of prescribed burning (i.e. area treated per annum), sufficient to limit the spread of unplanned fires under severe weather condition through the creation of a mosaic of low fuel patches in the landscape, were predicted to lead to high risk of extinction of both obligate seeder functional groups (over 200 years) and decline in resprouters. These results cast doubt on the popular notion that broad-scale 'mosaic' burning is an effective and ecologically sustainable tool for the management of wildfires.

Further modelling (Williams & Bradstock 2000, Bradstock & Gill in press) has demonstrated that a strategic, rather than a broad-scale approach to use of prescribed fire (e.g. intensive treatment of urban interface and other key buffer areas), offers the best solution in urbanised landscapes containing vegetation with obligate seeders, as typified in the Sydney region, where fire management must achieve concurrent human protection and conservation objectives.

The modelling approaches discussed above have so far considered single species, rather than the response of the plant community as a whole. Extension of such approaches to the community level will require consideration of interactions between functional groups and strata within vegetation. Overstorey and understorey interactions (Keith & Bradstock 1994, Tozer & Bradstock in review) in proteaceous shrub/heathlands and their effect on overall floristics will be strongly influenced by fire regimes, given the demographic lability of the overstorey. Keith and Bradstock (1994), Tozer and Bradstock (in review) have hypothesised that the suppressing effects of overstorey are such that an unstable fire regime must prevail for maintenance of full floristic diversity. Bradstock et al. (1995) proposed a conceptual model that positively related variance in fire regimes (fire-intervals in particular) to floristic composition. It is noteworthy that this conceptual model, built on a foundation of demographic studies on individual overstorey species (e.g. Bradstock & O'Connell 1988) and specific overstorey/understorey interactions (Keith & Bradstock 1994, Tozer & Bradstock in review), is corroborated by studies of community floristic composition in relation to fire regimes (Morrison et al. 1995, Cary & Morrison 1995). Bradstock et al. (1995) quantified guidelines for management that would lead to a domain of variable

fire regimes, sufficient to maintain floristic diversity. Their guidelines are intended for use as a simple decision support system to guide managers about choice of appropriate fire regimes within an adaptive framework (Bradstock 1999, Gill et al. in press, Keith et al. in press b).

Such an overview indicates that vegetation in the infertile habitats of the Sydney region dominated by Proteaceae, is inherently dynamic. Co-existence of species, at least at the point scale, may require instability of dominants in particular, perhaps with the necessity for dramatic fluctuations in density over relatively short periods of time. The fire regimes necessary to generate a shifting mosaic of 'unstable' patches in this manner but at the same time allowing for adequate dispersal and recolonisation of key species are currently unknown. The spatial modelling approaches described above offer an obvious means of exploring the problem.

Another possibility is that 'local instability' of key species may not always be driven by the influence of exogenous disturbances such as fire. Bond et al. (1995) used a population model to demonstrate that simple density-dependent effects on fecundity in South African proteaceous shrubs could generate chaotic population dynamics. The nature of such density-dependent effects on fecundity remain unexplored for analagous species in the Sydney region, though Bradstock (1985) and Bradstock and O'Connell (1988) showed that variations in soil depth may influence fecundity in bradysporous shrubs. Given the complex gradients in strata, soil depth and resultant soil moisture that are found at a variety of scales in sandstone-based habitats in the region, there is considerable potential for exploration of interactions of habitat-driven and endogenous effects on demography.

We hypothesise that the ultimate contribution of heterogeneity of the fire regime to maintenance of floristic diversity, will be constrained by habitat diversity and such endogenous demographic effects. A challenge for the future will be to carry out observations, experiments and modelling, at landscape scales, sufficient to provide critical insight into these processes.

General comments on fire interactions

While work on effects of fire on interactions between populations of bradysporous resprouting and those of obligate-seeding woody-fruited Proteaceae has allowed greater understanding, and thus a firmer basis for managing, certain heaths in the Sydney region, there is still much to be understood about effects of fire on Proteaceae. There is greater understanding of the effects of fire on Proteaceae in the region's infertile habitats, where Proteaceae are both diverse and abundant, than in more fertile habitats, where they are neither diverse nor abundant. Even in Proteaceae from infertile habitats, there is still much to be learned about effects of fire on their populations, particularly in those with soil seed banks and especially among resprouters among this group. In Proteaceae with soil seed banks, less is known in those species in which the unit of dispersal is either a fleshy fruit in species of *Persoonia* or a small achene as in *Conospermum* than in species of *Grevillea* where units dispersed are seeds. The Sydney region will continue to provide particularly fruitful opportunities for understanding effects of fire on Proteaceae and, more generally, the

ecology of plants in fire-prone habitats. Such studies are badly needed if we are to meet the challenges of conserving their populations and the dynamics of their interactions across the region's fire-prone landscapes.

Questions for research:

1. What responses to fire have populations of *Helicia glabriflora, Stenocarpus salignus* and *Lomatia myricoides*?
2. Do populations of obligate-seeding bradysporous Proteaceae have slower dynamics (slower growth, rates of maturation and longer juvenile periods) at higher altitudes in the Blue Mountains than on the coast?
3. Among obligate-seeding populations, are responses to fire in species of *Conospermum* and *Persoonia* similar to those in species of *Grevillea*?
4. Can changes of abundance across intervals between fires be modelled in obligate-seeding Proteaceae with soil banks in a similar way to the modelling of Bradstock and O'Connell (1988) in obligate-seeding populations of two bradysporous species of Proteaceae?
5. Data are required on population processes to understand and predict fire effects better in populations of species such as *Telopea speciosissima* and *Lomatia silaifolia*, in which fire stimulates flowering and seed release follows in the first two years or so after fire.
6. What is the juvenile fire-tender period in each resprouting bradysporous species of Proteaceae?
7. How and when does seedling recruitment occur in populations of resprouting Proteaceae with soil seedbanks in fire-prone habitats?
8. Is it an invariable rule that juveniles of resprouting species of Proteaceae become fire-tolerant long before they reach reproductive maturity?
9. Are there consistent differences between seedlings of resprouters and those of obligate-seeders in rates and patterns of growth among Proteaceae of the Sydney region?
10. Among woody-fruited Proteaceae of the Sydney region, do resprouters typically have fewer but larger viable seeds per plant than obligate-seeders?
11. In Proteaceae of the Sydney region, are the differences between characteristics of resprouting and those of obligate-seeding populations within those species that have both types as great as differences between species that just have one or the other sort of population?
12. How large an area is required to conserve indefinitely heaths where populations of bradysporous resprouting and obligate-seeding woody-fruited Proteaceae are dynamically co-occurring?

Concluding remarks

The foregoing review reveals an enormous range of interesting features of the Proteaceae of the Sydney region. It also identifies a large number of questions about

ecological and evolutionary processes that are at the cutting edge of our current knowledge. The diversity of taxa of Proteaceae, the range of habitat, soil and climatic zones they occupy, the variety (even among populations within species) of life-histories, fire responses, floral morphologies, pollinator types and breeding systems combine to make this family in the region a rich 'test bed' for many of these questions.

Proteaceae of the Sydney region increase in diversity and abundance inversely with fertility of habitats, as seems to be the case in south-western Australia (Lamont 1981). Much of the work done on the ecology of Proteaceae from infertile habitats in south-western Australia and in the Sydney region appears to produce comparable findings. It remains to be shown whether there are differences in them that can be related to differences in climate between the two regions. Work done on Proteaceae in the Sydney region has contributed particularly strongly to understanding of fire effects on populations of Proteaceae from infertile habitats and understanding breeding systems in them.

In the wider context of Australia, there is a need to achieve a more balanced understanding of the ecology of the Proteaceae. Little is known of the ecology of the Proteaceae that are endemic to the rainforests of north-eastern Queensland, and indeed of rainforest Proteaceae in general, including in the Sydney region. Similarly, little appears to be known of the ecology of the Tasmanian endemic genera *Agastachys*, *Cenarrhenes* and alpine *Bellendena*, or of alpine Proteaceae in general. Also, in the wide-ranging and diverse genera of *Hakea* and especially *Grevillea*, there is a scope for understanding whether particular characteristics change across the species with types of habitat they inhabit. In such a search for relationships between variation in habitat and plant characteristics in these genera, and indeed more widely in the family as a whole, the scheme of Westoby (1998) may be useful. In its use of leaf specific area, height of plant and seed mass, it might yield very different patterns of variation with variation in habitat in the Proteaceae than in the Myrtaceae. The Proteaceae tend to have sclerophyllous leaves in rainforest (Johnson & Briggs 1975) and, in the Proteaceae, seed mass appears not to reach such low levels as in some Myrtaceae and, within a given habitat, to have strong phylogenetic restraints (cf. small achenes of *Conospermum* with large seeds of some species of *Banksia* or *Grevillea*). It is clear that, in the ecology of Proteaceae, much remains to be understood both at the detailed level of demography or, more broadly, in terms of comparative investigation of plant characteristics and habitats across the whole of Australia.

Questions for research:

1. Have the Proteaceae of the rainforests of the Queensland moist tropics features not shared by other Australian Proteaceae?
2. Similarly, have Tasmanian Proteaceae endemics unique ecological characteristics?
3. In the wide-ranging genera *Grevillea* and *Hakea*, are there characteristics that change consistently across the species along gradients of fertility or moisture?
4. What patterns are apparent in the Proteaceae when the scheme of Westoby (1998) is applied to characteristics across habitats and species in the family?

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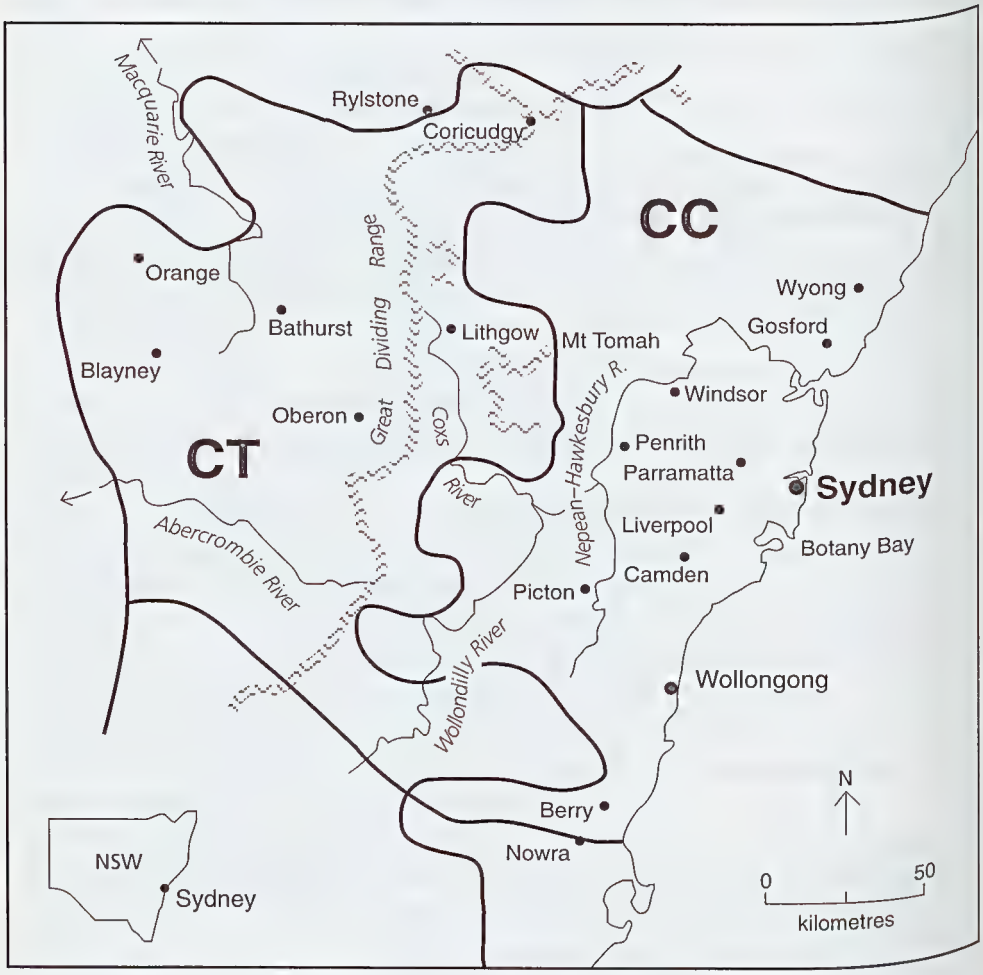

Map of the Sydney region

For the Ecology of Sydney Plant Species the Sydney region is defined as the Central Coast and Central Tablelands botanical subdivisions.

Ecology of Sydney plant species

Part 7b Dicotyledon families Proteaceae to Rubiaceae

Doug Benson and Lyn McDougall

Abstract

Benson, Doug and McDougall, Lyn (National Herbarium of New South Wales, Royal Botanic Gardens, Sydney, Australia 2000. Email: doug.benson@rbgsyd.nsw.gov.au) 2000 Ecology of Sydney plant species: Part 7b Dicotyledon families Proteaceae to Rubiaceae. Cunninghamia *6(4) 1016–1202.* Ecological data in tabular form are provided on 246 plant species of the families Proteaceae to Rubiaceae, 216 native and 30 exotics, occurring in the Sydney region, defined by the Central Coast and Central Tablelands botanical subdivisions of New South Wales (approximately bounded by Lake Macquarie, Orange, Crookwell and Nowra). Relevant Local Government Areas are Auburn, Ashfield, Bankstown, Bathurst, Baulkham Hills, Blacktown, Blayney, Blue Mountains, Botany, Burwood, Cabonne, Camden, Campbelltown, Canterbury, Cessnock, Concord, Crookwell, Drummoyne, Evans, Fairfield, Greater Lithgow, Gosford, Hawkesbury, Holroyd, Hornsby, Hunters Hill, Hurstville, Kiama, Kogarah, Ku-Ring-Gai, Lake Macquarie, Lane Cove, Leichhardt, Liverpool, Manly, Marrickville, Mosman, Mulwaree, North Sydney, Oberon, Orange, Parramatta, Penrith, Pittwater, Randwick, Rockdale, Ryde, Rylstone, Shellharbour, Shoalhaven, Singleton, South Sydney, Strathfield, Sutherland, Sydney City, Warringah, Waverley, Willoughby, Wingecarribee, Wollondilly, Wollongong, Woollahra and Wyong. The study area falls within the Sydney Basin IBRA Bioregion.

Families are: Proteaceae, Ranunculaceae, Resedaceae, Rhamnaceae, Rosaceae, Rubiaceae.

Data are derived from herbarium collections, literature and field observations. It is hoped that the many, often alarming gaps in the information available will stimulate much-needed research into the ecology of more of the species. Information is provided so far as available to us for each plant species in the following categories:

Life History: Growth form, vegetative spread, longevity, primary juvenile period (time from germination to fruiting), reproduction, flowering and fruiting times, fruit/seed type, dispersal, establishment and growth, fire response, interaction with other organisms.

Distribution: Status/origin (native/naturalised), botanical subregions, distribution in Sydney area, selected locations.

Habitat: Habitat, altitude, annual rainfall, typical local abundance, vegetation, substrate, exposure.

Conservation: Conservation status.

Introduction

The *Ecology of Sydney plant species* aims to provide ecological information on native and naturalised Sydney plants. Particular emphasis has been given to data that are relevant for ecologists and natural area managers, for people involved in bush regeneration, land rehabilitation and landscape design, for researchers in many fields and for a wide range of people who are interested in bushland and native plants. Species-specific information is also relevant to environmental impact assessment and to studies involving changes in drainage, water movement, wind exposure, nutrient conditions and fire regimes on plant species and plant communities. Information included covers growth form, flowering and fruiting times, longevity and maturation periods, pollination and seed dispersal data, distribution, habitat and plant community, as well as responses to fire and disturbance where available and is complementary to the descriptive texts in taxonomic handbooks such as the *Flora of New South Wales* (Harden 1990–93).

Part 7b of the *Ecology of Sydney plant species* covers the Dicotyledon families alphabetically from Proteaceae to Rubiaceae.

Part 8, Rutaceae to Zygophyllaceae will be published in 2001.

Methods

Part 7b follows the format used in Parts 1–7a (Benson & McDougall 1993, 1994, 1995, 1996, 1997, 1998, 1999). The Sydney region is defined as the Central Coast and Central Tablelands botanical subdivisions (i.e. approximately bounded by Lake Macquarie, Orange, Crookwell and Nowra) (Fig. 1). This is the area broadly covered by *Flora of the Sydney Region* (Carolin & Tindale 1993), with the exception that the Hunter Valley is not included here since it lies within the North Coast and Central Western Slopes subdivisions. Relevant Local Government Areas are Auburn, Ashfield, Bankstown, Bathurst, Baulkham Hills, Blacktown, Blayney, Blue Mountains, Botany, Burwood, Cabonne, Camden, Campbelltown, Canterbury, Cessnock, Concord, Crookwell, Drummoyne, Evans, Fairfield, Greater Lithgow, Gosford, Hawkesbury, Holroyd, Hornsby, Hunters Hill, Hurstville, Kiama, Kogarah, Ku-Ring-Gai, Lake Macquarie, Lane Cove, Leichhardt, Liverpool, Manly, Marrickville, Mosman, Mulwaree, North Sydney, Oberon, Orange, Parramatta, Penrith, Pittwater, Randwick, Rockdale, Ryde, Rylstone, Shellharbour, Shoalhaven, Singleton, South Sydney, Strathfield, Sutherland, Sydney City, Warringah, Waverley, Willoughby, Wingecarribee, Wollondilly, Wollongong, Woollahra and Wyong. The study area falls within the Sydney Basin IBRA bioregion.

The Sydney region, as defined here, includes approximately 3500 plant species, both native and naturalised. To deal effectively with this number, the work has been divided into parts each of approximately 350 species based on plant families beginning with ferns, Cycads and Gymnosperms, and then Dicotyledon and Monocotyledon families. Within these groups, families, genera and species are arranged alphabetically:

Part 1: Ferns, Fern allies, Cycads and Conifers, Dicotyledon families Acanthaceae to Asclepiadaceae (*Cunninghamia* 3(2) 1993)

Part 2: Dicotyledon families Asteraceae to Buddlejaceae (*Cunninghamia* 3(4) 1994)

Part 3: Cabombaceae to Eupomatiaceae (*Cunninghamia* 4(2) 1995)

Part 4: Fabaceae (*Cunninghamia* 4(4) 1996)

Part 5: Flacourtiaceae to Myrsinaceae (*Cunninghamia* 5(2) 1997)

Part 6: Myrtaceae (*Cunninghamia* 5(4) 1998)

Part 7a: Nyctaginaceae to Primulaceae (*Cunninghamia* 6(2) 1999)

Part 7b: Proteaceae to Rubiaceae (*Cunninghamia* 6(4) 2000)

Part 8: Rutaceae to Zygophyllaceae

Part 9: Monocotyledon families

Part 10: Monocotyledon families

For each species (and generally for subspecies) a data sheet is prepared incorporating life history, distribution and habitat data from specimens in the National Herbarium of New South Wales; this information is entered in a database together with data from literature sources both published and unpublished. References have been cited where appropriate but for unreferenced data responsibility has been assumed by the authors. A provisional compilation sheet with the available information is then prepared and distributed to interested persons for comments and additions/alterations. This compilation is then published in parts in the summer issue of *Cunninghamia*, with the subsequent long-term aim of producing a book at the completion of the ten parts. This will allow the incorporation of new and additional material.

Part 8, Rutaceae to Zygophyllaceae, is planned for publication in 2001, and any information that readers would like included should be sent to the authors by 30 June 2001.

Ecological review papers may be appropriate for families in future issues, particularly the major families e.g. Rutaceae, but papers would also be welcomed for smaller families. Authors interested in contributing such papers should contact the Scientific Editor.

Information categories

For each species or subspecies, information is presented under headings relating to different life-history aspects, each with further subdivisions. Emphasis has been given to understanding the species in its wild habitat. For this reason data on cultivation and artificial propagation, available in horticultural books, are generally not included. Likewise information on weed control is not given. Generally, the categories are broadly interpreted and since the project aims to stimulate further investigation, we welcome the addition of extra data on any other aspects of the plant's ecology.

A 'comments' section has been deliberately avoided — for all information retrieval purposes, all ecological material should be attributable to some life history aspect of the plant or its habitat although even with our broad categories there have been problems with 'Vegetation' and 'Substrate' sections for specialised lifeforms such as mistletoes. The main purpose of this information is to give a picture of the ecology of particular species as is currently known. It is not primarily for comparative purposes although it can be used in this way. One of our original aims was to demonstrate that closely related species may have different ecologies and that to generalise within genera for example rather than look at a particular species is an over simplification. We have also included reference to individualistic information resulting from specific research that will not necessarily be available for all species.

Similarly where we have observations on the effects of factors such as drought on particular species we have included these, though we have not included a category for 'drought' because of difficulties in definition. One of our aims is to be open-ended, to point out that there are many gaps in the ecological knowledge and to indicate areas and species where future work may be particularly useful.

Botanical nomenclature

Family/Genus/Species: Names currently recognised at the National Herbarium of NSW and mostly as used in *Flora of New South Wales.*

Common name: Names used in *Flora of New South Wales.*

Life history

Growth form: Brief description.

Source: *Flora of New South Wales.*

Vegetative spread: Indication of whether localised expansion or spread is possible from an individual by rhizome, stolon, rootsucker etc. Important in determining ability of species to colonise immediate local area. Does not include vegetative distance-dispersal which is included under Establishment & Growth (diaspore).

Source: Flora descriptions, Herbarium specimens, field observations.

Longevity: Average potential life-span under natural conditions — range in years where possible, indefinite, where death is not a result of inherent growth e.g. continued rhizomatous growth. Longevity may be shorter in cultivation. There are very few references in the literature to the longevity of species or records of individual plants, particularly of the longer-lived species, yet this is an important factor in assessing importance of recruitment and changes in plant communities.

Most of the estimates given are based on the authors' judgement, based on the shape, size and growth rates of individuals, and the authors' experience in the field over 25 years, together with any historical data available. The figures given are conservative and represent minimal average ages. The authors would not be surprised if much greater ages are achieved in many cases.

Source: literature, authors' assessment from field observations.

Primary juvenile period: time taken from germination to produce first fruits or spores. Gill (1975) uses the term for the period from germination to flowering but the period to fruit maturity is more significant ecologically. Secondary juvenile period is time taken for individual to recover to produce fruit after major damage e.g. from fire, but applicable only if species regularly resprouts. The time required to accumulate a seedbank sufficient to ensure reasonable recruitment in the event of mass mortality is also an important consideration. Primary and secondary juvenile periods should not be considered as absolute and they may vary spatially as a function of habitat factors (moisture availability, nutrients etc.) and temporally (e.g. climatic variation).

Source: literature, field observations.

Reproduction: for Angiosperms, reproduction is separated into:

Flowers: predominant flower colour, flowering period — range of months and, where possible, peak month based on frequency of herbarium collections. Pollination vectors.

Fruit: fruit shape and size, particularly with respect to potential dispersal agents. Maturation period. Seed size and number.

Source: Herbarium specimens, field observations, *Flora of New South Wales*, literature.

Establishment and growth: diaspore type (including vegetative), dispersal agent. Germination requirements: seedbank presence, dormancy, growth rates, seasonality, deciduousness etc. [notes on propagation in cultivation may be given where these imply similar behaviour under natural field conditions e.g. insights into seed germination inhibition].

Source: literature, field observations.

Fire response: general response of mature plant to fire, in particular whether it generally resprouts or is killed (see also Gill 1981, Gill & Bradstock 1992). Seedling recruitment associated with fire is included under establishment and growth. Entries such as 'probably killed' mean that a species has no obvious morphological characteristics likely to assist in surviving and resprouting following fire. While species that resprout after fire may be readily noted, the death of individuals may not be observed unless the occurrence of the species in the area was well known prior to the fire.

For a given species some populations may be capable of resprouting while other populations may be killed. This may explain cases where contradictory evidence has been given though response to fire in some species may depend on fire intensity.

In view of the limited information available for many species, the categories of Gill and Bradstock have not been applied at this stage.

Source: field observations, literature.

Interaction with other organisms: symbiosis, predators, diseases etc.

Source: mainly literature.

Distribution

Status/origin: native or naturalised, region of origin, source and date of introduction/ naturalisation. Naturalised species indicated by an asterisk following the botanical name.

Source: *Flora of New South Wales*, literature.

Botanical subregions: occurrence of species in botanical subdivisions of NSW, other states and countries.

Source: National Herbarium of New South Wales.

Distribution in Sydney region: main geographic regions occupied by species.

Source: Herbarium specimen records.

Selected locations: restricted to about 10 localities for each taxon reflecting natural geographical range of species in the Sydney area. Earliest collection dates are given for some species, particularly exotic species. Recent collection sites indicated where possible. Locality data must be interpreted carefully. The record may be based on an old specimen or observation record and the species may no longer be present at the site. However a knowledge of the original distribution may be important in showing up particular habitat requirements of the species.

Source: Herbarium specimen records.

Habitat

Specific data refer to Sydney area unless stated otherwise.

Habitat: brief generalised description.

Source: Herbarium specimen records, field observations.

Altitude: approximate altitudinal range (m +/- 100 m) occupied by the species,

Source: Herbarium specimen records.

Annual rainfall: approximate annual rainfall range (mm +/- 100 mm) for sites occupied by the species.

Source: Bureau of Meteorology (1979).

Typical local abundance: most frequent recordings (scale: dominant/frequent/ occasional/rare)

Source: Herbarium specimen records.

Vegetation: main structural type with typical associated species where available.

Source: Herbarium specimen records, field observations, literature.

Substrate: geology, soil, moisture supply.

Soil nutrient rating scale: very fertile (high nutrient) (e.g. basalt soils)/ fertile (moderate nutrient)/ infertile (low nutrient)/ very infertile (very low nutrient) (e.g. sands).

Soil salinity scale: hypersaline/ saline/ brackish/ fresh.

Source: Herbarium specimen records, field observations, literature.

Exposure:

Exposure scale: exposed/ indifferent/ sheltered.

Shading scale: deep shade/ mid shade/ light shade/ no shade.

Source: Herbarium specimen records, field observations, literature.

Conservation

Conservation: national significance listing (Briggs & Leigh 1996), with current updating for Rare or Threatened Australian Plants (ROTAP) database maintained by NSW NPWS; inclusion on schedules of the NSW *Threatened Species Conservation Act 1995*; comments on regional significance and adequacy of conservation within Sydney area are based on authors' knowledge of the abundance of species and their primary occurrence in major conservation areas. These comments apply to the Sydney region; a species may be common or rare elsewhere. 'Probably' is used in many cases as it is the authors' views that a definite categorisation of 'adequately conserved' needs to be based on a better knowledge of the species' biology and distribution than we have at present for most species.

Source: Herbarium records, field observations, literature.

General comments on part 7b

Part 7b covers 246 plant species of the families Proteaceae to Rubiaceae, 216 native and 30 naturalised exotics.

Excluded from this work are a number of exotic species that do not appear to be truly naturalised in the Sydney region (*Potentilla anserina* subsp. *anserina, Rubus chloocladus, Rubus ursinus, Asperula arvensis, Galium divaricatum*).

General aspects of the ecology of the Proteaceae family are covered in the accompanying paper by Myerscough, Whelan and Bradstock (page 951) who include a list of research topics of potential interest. Other major plant groups in this part include *Pomaderris, Ranunculus* and Rubiaceae. Very little ecological work has been done on these groups.

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Dicotyledon families Proteaceae to Rubiaceae

Banksia aemula PROTEACEAE

Life history

Growth form: Shrub to 4 m high with spreading habit. *B. aemula* is similar to the very closely related *B. serrata* but has a club-shaped pollen-presenter and narrower leaves. The bark is more easily shed (e.g. after fire) than in *B. serrata* and exposed bark more foxy-brown with surface appearing to consist of embedded small spheres (P. Myerscough pers. comm.).
Vegetative spread: No.
Longevity: More than 100 years.
Primary juvenile period:
Flowers: Pale yellow to greenish cream, April–May. Flower spike produced at the end of the current year's shoot or on a short lateral shoot, the next year's shoots grow from immediately below the spike (Blake 1971). Source of nectar and pollen for Common Blossum Bat *Syconycteris australis* (Law 1994), Rainbow Lorikeet *Tricholglossus haematodus* (Barker & Vestjens 1989), Scarlet Honeyeater *Myzomela sanguinolenta* (Barker & Vestjens 1990).
Fruit/seed: Woody capsules on a cone, opening spontaneously when mature or remaining closed until burnt (George, 1981). Winged seed: 40-47 mm long.

Dispersal, establishment & growth: Diaspore: seeds, gravity and short distance wind-dispersed. No dormancy mechanism (Heslehurst 1979), germination period 44 days (Simmons 1968), effective germination only in seeds exposed to temperatures up to 100°C; slow growth rate in step with slow rate of availability of nutrients in soil (Siddiqi et al. 1976).

Fire response: Resprouts from lignotubers; fire triggers release of seed from canopy-stored seedbank (Siddiqi et al. 1976), also resprouts with epicormic shoots after a burn seedlings are often seen, though few reach maturity (George 1981),
Interaction with other organisms: Host of Banksia Web-covering Borer *Xylorycta strigata* (Elliot & Jones 1986). Fungi that cause leaf spots are: *Asterina* sp., *Lineostroma banksiae, Phoma banksiae-integrifoliae; Cephaleuros virescens* causes algal leaf spot (B. Summerell pers. comm.).

Distribution

Status/origin: Native.
Botanical subregions: NC CC; Qld.
Distribution Sydney area: Coastal headlands, with inland occurrence at Agnes Banks.
Select locations: CC: Wybung Point (Lake Munmorah), Frazer Park, Bouddi NP, Agnes Banks NR, North Head, Centennial Park, Bellevue Hill, Rockdale (1898), La Perouse.

Habitat

Habitat: Old, leached sand deposits.
Altitude: 0–100 m **Annual rainfall:** 800–1200 mm
Typical local abundance: Frequent–occasional.
Vegetation: Heath e.g. with *Monotoca elliptica, Xanthorrhoea resinifera, Corymbia gummifera, Allocasuarina distyla, Lambertia formosa*; Eastern Suburbs Banksia Scrub; woodland e.g. with *Eucalyptus sclerophylla, E. parramattensis, Leptospermum trinervium, Conospermum taxifolium, Ricinocarpos pinifolius* at Agnes Banks (Benson 1981).
Substrate: White, leached dune sand, often Pleistocene, low nutrients, well-drained.
Exposure: Full sun.

Conservation

Conservation: Reported from Munmorah SRA, Bouddi NP, Sydney Harbour NP (North Head), Botany Bay NP and Agnes Banks Nature Reserve. La Perouse is southern geographical limit. Major component of Eastern Suburbs Banksia Scrub and Agnes Banks Woodland Endangered Ecological Communities, listed under NSW *Threatened Species Conservation Act 1995.*

Banksia penicillata *(B. conferta* var. *penicillata)* **PROTEACEAE**

Life history

Growth form: Shrub to 4 m, without a lignotuber.
Vegetative spread: No.
Longevity: ?30–50 years.
Primary juvenile period:
Flowers: Yellow, March–June
Fruit/seed: Cone with more than 100 woody capsules usually remaining closed and retaining canopy-stored seedbank until burnt, but some opening spontaneously (George 1981). Winged seed 14–17 mm long.
Dispersal, establishment & growth: Diaspore: winged seed, gravity-dispersed. Recruitment after fire or perhaps disturbance that bares soil.
Fire response: Killed by fire, re-established from seed released from burnt cones.
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: **CC CT** CWS.
Distribution Sydney area:
Select locations: **CC:** Culoul Range. **CT**: Cullen Bullen, Ben Bullen SF, Newnes SF, Clarence, Bell.

Habitat

Habitat: Rocky sandstone situations at the top and base of cliffs or steep slopes and around outcrops.
Altitude: 500–1100 m **Annual rainfall:** 900–1100 mm
Typical local abundance: Frequent–occasional.
Vegetation: Sclerophyllous open-forest or woodland e.g. with *Eucalyptus sclerophylla, E. sieberi, E. radiata, E. piperita, Syncarpia glomulifera, Angophora bakeri, Leptospermum trinervium;* heathland e.g. with *Allocasuarina nana.*
Substrate: Skeletal sandy soil over sandstone often associated with pagoda rock outcrops, low nutrients, well-drained.
Exposure:

Conservation

Conservation: Coded 3RC- on national rare species list (Briggs & Leigh 1996). Reported in Wollemi NP.

Banksia cunninghamii subsp. *cunninghamii* PROTEACEAE

Life history

Growth form: Tree or shrub to 6 m high, without a lignotuber.
Vegetative spread: No.
Longevity: ?30–50 years.
Primary juvenile period:
Flowers: Yellow, dense in a spike-like arrangement 6–15 cm long on a woody stem,
Fruit/seed: Woody capsules 10–14 mm long on a cone; seeds winged.
Dispersal, establishment & growth: Diaspore: seed, released after fire or spontaneously, gravity or short-distance wind dispersed.
Fire response: Killed (George 1981).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: **CC** SC **CT**; Qld, Vic.
Distribution Sydney area:
Select locations: **CC**: Boorai Creek, O'Hares Creek. **CT**: Rylstone, Newnes Plateau, Lithgow, Bell, Katoomba, Wentworth Falls, Jenolan R., Kanangra Walls, Fitzroy Falls.

Habitat

Habitat: Sheltered slopes of gullies.
Altitude: 200–1200 m **Annual rainfall:** 900–1400 mm
Typical local abundance: Frequent.
Vegetation: Eucalypt open-forest e.g. *Eucalyptus piperita, Angophora costata* with *Corymbia gummifera, Eucalyptus sieberi* (Keith 1994), *Eucalyptus oreades, E. mannifera, E. radiata, E. cypellocarpa, E. dalrympeana* in Upper Blue Mountains.
Substrate: Sandstone, moist sands and sandy loams, shallow soil, well-drained (Keith 1994), low nutrients.
Exposure: Sheltered sites.

Conservation

Conservation: Reported from O'Hares Creek (Keith 1994), Blue Mountains NP, Kanangra Boyd NP.

Banksia ericifolia var. *ericifolia* PROTEACEAE

Life history

Growth form: A shrub or small tree. Prostrate form genetically different (Auld & Morrison 1992). Appears to hybridize with *B. spinulosa* var. *spinulosa* (Harden 2000).
Vegetative spread: No.
Longevity: Medium. 25–60 years (D. Keith pers. comm.).
Primary juvenile period: 8–9 years at Brisbane Water NP (Benson 1985), 5 years (Bradstock & O'Connell 1988), 5 years at Lane Cove (P. Kubiak pers. comm.), 4 years (at Wollangambe Wilderness) but no fertile fruits (R. Lembit (pers. comm.).

Flowers: Golden-brown, April–August. Flowers produced at end of shoots more than 3 years old (Blake 1971). Buds open from top of the spike, downwards (Blake 1971). More nectar present at dawn than dusk; flowers visited by diurnal and nocturnal insects (Paton & Turner 1985). Pollinated by mammals and marsupials, *Rattus fuscipes, Antechinus stuartii* and birds. Flowers visited by Honeybees for nectar and pollen (Paton & Turner 1985), and native bees for pollen; birds: Eastern Spinebill *Acanthorhynchus tenuirostris*, Noisy Miner *Manorina melanocephala*, New Holland Honeyeater *Phylidonyris novaehollandiae*, and Brush Wattlebird *Anthochaera chrysoptera* feed on nectar (P. Kubiak pers. comm.), Yellow-faced Honeyeater *Lichenostomus chrysops*, Fuscous Honeyeater *Lichenostomus fuscus*; White-eared Honeyeater *Lichenostomus leucotis*, New Holland Honeyeater *Phylidonyris novaehollandiae*, White-cheeked Honeyeater *Phylidonyris nigra* feed on nectar (Barker & Vestjens 1990).

Fruit/seed: Cone with capsules 15–20 mm long that develop up to a year after flowering. Seed weight 24.2 mg ± 1.0 (Hammill et al. 1998), winged seed 17-20 mm long, retained in capsules for several years as canopy-stored seedbank. Seed production is greater when cross-pollination occurs as opposed to self-pollination (Paton & Turner 1985).

Dispersal, establishment & growth: Diaspore: seed, gravity and short distance wind-dispersed. Average dispersal distance 7.6 m (Honig et al 1992). Limited spontaneous release of seed during inter-fire period (Keith 1991). Germinates without treatment. Germination 17 days at 15°C (Honig et al. 1992), 22 days at 24–31°C (Zammit & Westoby 1987b). Recruitment mainly after fire. Effective germination only in seeds exposed to temperatures up to 100°C; slow growth rate in step with slow rate of availability of nutrients in soil (Siddiqi et al 1976). Seedling establishment occurs during first year after fire (Bradstock & Auld 1987).

Fire response: Plants killed, seeds survive fire insulated from heat in thick woody follicles which open following fire. Seed release earlier and at a faster rate after high intensity fire than low intensity fire (Bradstock & Myerscough 1981). Seeds not released at temperatures less than 200°C; takes 45 days for half seed-store to fall after high intensity wildfire (Zammit & Westoby 1987b). Vigorous seedling regeneration usually follows fire. Seedlings show little capacity for rapid exploitation of any temporary increase of available nutrients after fire (Siddiqui et al. 1976). Internode number may be used as indicator of period since last burn (at least over 10–25 year time scale).

Interaction with other organisms: Moth larvae *Arotrophora* sp. reduce seed set (Zammit & Hood 1986). Shoot damage but not eaten by rabbits (P. Kubiak pers. comm.). Fungi *Capnodium salicinum* and *Chaetasbolisia* sp. are found on the leaves and a *Botryosphacria* sp. causes a canker disease (B. Summerell pers. comm.).

Distribution

Status/origin: Native.

Botanical subregions: **CC** SC **CT** ST.

Distribution Sydney area: Coast and Upper Blue Mountains.

Select locations: **CC**: Kulnura, Avalon, Wahroonga, Cheltenham, North Head, Centennial Park, La Perouse, Bundeena, Carrington Falls, Sublime Point. **CT**: Rylstone, Glen Davis, Newnes SF, Blackheath, Woodford, Robertson.

Habitat

Habitat: Ridges, hillsides, creekbanks.

Altitude: 0–1200 m **Annual rainfall:** 900–1600 mm

Typical local abundance: Frequent.

Vegetation: Open woodland e.g. with *Eucalyptus haemastoma, E. racemosa, Angophora hispida*; heath e.g. with *Allocasuarina nana*; coastal scrub e.g. with *Monotoca elliptica, Acacia suaveolens, Eriostemon australasius, Kunzea ambigua.*

Substrate: Sandy soil on Hawkesbury and Narrabeen Sandstones. Low-medium nutrient soils, periodically poorly-drained.

Exposure: Full sun.

Conservation

Conservation: Widespread, Rylstone is northern geographical limit. Appears to be adequately conserved, however, some populations could be threatened by frequent fires at less than 10 year intervals. Reported in Bouddi NP, Brisbane Water NP, Marramarra NP, Muogamarra Nature Reserve, Ku-ring-gai Chase NP, Garigal NP, Lane Cover NP, Sydney Harbour NP, Royal NP.

Banksia integrifolia subsp. *integrifolia* PROTEACEAE

Coast Banksia

Life history

Growth form: Tree to 16 m high, more rarely shrubby, with whorled leaves.
Vegetative spread: Some root-suckering apparent in undisturbed adult populations if the roots are uncovered or disturbed (at Garie, Vaucluse). Root suckering important for recruitment in dry sandy scrub at Elderslie.
Longevity: long ? 100–150 years.
Primary juvenile period:
Flowers: Pale yellow, January–June. Synchronous flowering. Honeybees, native bee, butterfly, and Eastern Spinebill *Acanthorhynchus tenuirostris* feed on nectar (P. Kubiak pers. comm.). Important source of nectar for honeyeaters in heathland (Pyke et al. 1993), foodplant of Fuscous Honeyeater *Lichenostomus fuscus* (Barker & Vestjens 1990), Flying Foxes feed on blossoms (NPWS 1992).
Fruit/seed: Thick woody capsules on a cone; winged seeds 10–12 mm long, released from all capsules by May.
Dispersal, establishment & growth: Diaspore: seed, gravity-dispersed, fire not necessary for seed shed. Requires day temperatures 14–21°C and night temperature 5–21°C for optimum germination, maximum germination 98% (Sonia & Heslehurst 1978).

Fire response: Plants generally killed, though this may depend on age and fire intensity (Hazard & Parsons 1977, Fox 1988). Some plants resprouted and others killed after high intensity fire 1/94 (at Lane Cove, P. Kubiak pers. comm.). Root suckering after fire has not been reported.
Interaction with other organisms: Larvae of moth *Xylorycta strigata* tunnel in the branches and feed on leaves (CSIRO 1991). Host to Cerambycid longicorn beetle *Paroplites australis* (Hawkeswood 1992b). Leaves of young plant eaten by wombat (Burns 1996). Blossoms eaten by Grey-headed Flying Fox *Pteropus poliocephalus*, Little Red Flying Fox *Pteropus scapulatus* (Eby 1995), Common Blossum Bat *Syconycteris australis* (Law 1994). Fungi recovered from leaves: *Asterina systema-solane, Capnodium salicinum, Episphaerella banksiae, Guignardia* sp., *Lembosia* sp., *Lineostroma banksiae, Pestalotiopsis* sp., *Plectosphaera banksiae, Vizella banksiae, Westea banksiae; Cephaleuros virescens* causes algal leaf spot (B. Summerell pers. comm.).

Distribution

Status/origin: Native.
Botanical subregions: NC **CC** SC **CT** NWP; Qld, Vic., Tas.
Distribution Sydney area: Mainly coastal, with localised inland populations e.g. Elderslie.
Select locations: **CC**: Norah Head, Woy Woy, Frenchs Forest, Manly, Rose Bay, Vaucluse, Kurnell, Elderslie, Stanwell Park, Picton Lakes, Shellharbour, Berry. **CT**: Wingello.

Habitat

Habitat: Consolidated sand dunes and along tidal inlets.
Altitude: 0–700 m **Annual rainfall:** 900–1400 mm
Typical local abundance: Frequent.
Vegetation: Coastal woodland and low woodland e.g. with *Angophora costata, Corymbia gummifera, Eucalyptus botryoides*; scrub e.g. with *Monotoca elliptica, Leptospermum laevigatum.*
Substrate: Sandy soil on consolidated sand dunes, alluvial sand, sandstones, low nutrients.
Exposure: Full sun to light shade.

Conservation

Conservation: Frequent in coastal sites, reported from Royal NP, Sydney Harbour NP, Ku-ring-gai Chase NP. Vulnerable in Western Sydney, where it is an important component of Elderslie Banksia scrub Endangered Ecological Community under NSW *Threatened Species Conservation Act 1995* (James et al 1999).

Banksia integrifolia subsp. ***monticola*** PROTEACEAE

(*Banksia integrifolia* var. *compar*)

Coast Banksia

Life history

Growth form: Tree 5–25 m high, with rough bark; leaves whorled.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Pale yellow, in a spike-like arrangement 5–12 cm long, March–April, September–November. Buds open from bottom to top of spike (McFarland 1985).
Fruit/seed: Cone with woody capsules 8–15 mm long, each capsule with 2 winged seeds.
Dispersal, establishment & growth: Diaspore: seed, released at maturity, gravity or short-distance wind-dispersed.
Fire response: Resprouts from epicormic buds (George 1981). Generally killed but occasionally resprouts (R. Lembit pers. comm.).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC NT **CT**.
Distribution Sydney area: Upper Blue Mountains.
Select locations: **CT**: Mt Wilson, Victoria Falls, Blackheath.

Habitat

Habitat: Steep slopes.
Altitude: 700–1000 m **Annual rainfall:** 1200–1400 mm
Typical local abundance: Occasional.
Vegetation: Eucalypt open-forest and rainforest margins.
Substrate: Clay soil on basalt, occasionally on sandstone, medium to high nutrients.
Exposure:

Conservation

Conservation: Blue Mountains population is at southern geographical limit.
Conservation status unknown.

Banksia marginata PROTEACEAE

Life history

Growth form: Spreading shrub or small tree to 12 m high. No lignotuber in Sydney populations but present in Victorian and Tasmanian populations. Occasionally hybridzes with *B. paludosa* where they grow together.
Vegetative spread: No.
Longevity:
Primary juvenile period: 5 years (at Lane Cove, P. Kubiak pers. comm.).
Flowers: Pale yellow, February–July. Flowers produced at the ends of shoots more than 3 years old (Blake 1971). Inflorescences with up to 1000 flowers, opening sequentially over several weeks; pollinated by nectar-feeding birds; plants self-compatible (Vaughton & Ramsey 1998). Flowers visited by Honeybee, butterfly, New Holland Honeyeater *Phylidonyris novaehollandiae* (P. Kubiak pers. comm.), Rainbow Lorikeet *Tricholglossus haematodus* (Barker & Vestjens 1989), Red Wattlebird *Anthochaera carunculata*, Yellow-faced Honeyeater *Lichenostomus chrysops*, White-plumed Honeyeater *Lichenostomus penicillatus*, Black-chinned Honeyeater *Melithreptus gularis*, Brown-headed Honeyeater *Melithreptus brevirostris*, New Holland Honeyeater *Phylidonyris novaehollandiae* (Barker & Vestjens 1990).
Fruit/seed: Woody capsules on a cone, often opening when mature but sometimes remaining closed until burnt; winged seeds 9–15 mm long. Seed weight 10.2 mg ± 0.4 (Hammill et al. 1998). Woody fruits develop about 6 months after flowering (Vaughton & Ramsey 1998). Pre-dispersal seed predation 20% (Northern Tablelands); viability of seed 98.8% (Williams & Clarke 1997).
Dispersal, establishment & growth: Diaspore: seed, gravity dispersed or short-distance wind-dispersed.
Fire response: Non-lignotuberous Sydney forms killed by fire, otherwise resprouts (George, 1981).
Interaction with other organisms: Host to Cup Moth larvae *Mecytha fasciata* (Common 1990). Host to Cerambycid longicorn beetle *Paroplites australis* (Hawkeswood 1992b). Wasp *Mesostoa kerri* causes stem galls (in S.A.,Austin & Dangerfield 1998). Fungi recovered from leaves: *Acrospermum gaubae, Argopericonia elegans, Asterina systema-solare, Botryosphaeria banksiae, Cladosporium* sp., *Cooksonomyces banksiae, Dimerium banksiae, Episphaerella banksiae, Periconiella* sp., *Satchmopsis australiensis, Tryssglobulus aspergilloides, Veronaea* sp. (B. Summerell pers. comm.).

Distribution

Status/origin: Native.
Botanical subregions: NC **CC** SC NT **CT** ST NWS CWS SWS SWP NWP; Vic., Tas., S.A.
Distribution Sydney area: Widespread
Select locations: **CC**: Berowra, Wahroonga, Manly, Rose Bay, Loftus, Sublime Point. **CT**: Newnes SF, Orange, Mt Lambie, Clarence, Blackheath, Oberon, Mt Werong, Berrima, Penrose.

Habitat

Habitat: Heath and woodland.
Altitude: 0–1200 m **Annual rainfall:** 800–1600 mm
Typical local abundance: Frequent.
Vegetation: Heath e.g. with *Banksia ericifolia, B. serrata, Lambertia formosa, Persoonia lanceolata, Angophora hispida*; woodland e.g. with *Eucalyptus sieberi, E. oreades, E. piperita, E. haemastoma, Corymbia gummifera, Eucalyptus stricta, E. mannifera, E. pauciflora*. Margin of upland mire (Kodela 1992).
Substrate: Sandy soils on sandstone, quartzite, granite, low nutrient, well-drained.
Exposure:

Conservation

Conservation: Probably adequately conserved in Sydney area. Reported from Marramarra NP, Muogamarra Nature Reserve, Ku-ring-gai Chase NP, Garigal NP, Lane Cove NP, Sydney Harbour NP, Royal NP, Blue Mountains NP.

Banksia oblongifolia PROTEACEAE

Life history

Growth form: Several-stemmed, up to 13 stems, shrub, to 3 m high, with lignotuber (Conran & Clifford 1987).
Vegetative spread: No.
Longevity: More than 60 years (D. Keith pers. comm.)
Primary juvenile period: More than 17 years (Keith 1996), more than 23 years (Zammit & Westoby 1987a).
Flowers: Pale yellow, dense in a spike-like arrangement 5–15 cm long on a woody stem, January–October, peak April–June. Honeybees and native bees feed on nectar and probably pollen; two species of ants, and birds Eastern Spinebill *Acanthorhynchus tenuirostris*, New Holland Honeyeater *Phylidonyris novaehollandiae*, Noisy Miner *Manorina melanocephala* fed on nectar (P. Kubiak pers. comm.).
Fruit/seed: Woody capsules 10–18 mm long, on a cone. Winged seeds 7–12 mm diam. (Conran & Clifford 1987), weight 12–24 mg (Westoby et al. 1990), held for several years as canopy-stored seedbank or until released following fire.
Dispersal, establishment & growth: Diaspore: seed, gravity and short distance wind-dispersed. Limited seed release from the canopy during the inter-fire period (Keith 1991). Germinates without treatment. (D. Keith pers. comm.). Slow growth rate Although able to grow on well-drained sites, it may be excluded by competition with *Banksia aemula* (Siddiqi et al. 1976).
Fire response: Stems killed, resprouts from lignotuber; seedling recruitment mainly after fire (Keith 1996). Seedlings show little capacity for rapid exploitation of any temporary increase in available nutrients after fire (Siddiqi et al. 1976). Secondary juvenile period 2 years; 4.5 years after high intensity fire 1/94 (at Lane Cove, P. Kubiak pers. comm.).
Interaction with other organisms: Fungi recovered from leaves: *Asterina systema-solare, Episphaerella banksiae, Lincostromea banksiae* (B. Summerell pers. comm.).

Distribution

Status/origin: Native.
Botanical subregions: NC **CC CT** CWS; Qld.
Distribution Sydney area: Mainly coastal plateaus.
Select locations: **CC**: Kulnura, Bateau Bay, Agnes Banks, Hornsby, St Ives, Collaroy, Mosman, Vaucluse, Neilsen Park, Kogarah, La Perouse, Lucas Heights, Waterfall, Appin, Bulli, Grose Vale. **CT**: Wentworth Falls.

Habitat

Habitat: Hillsides, ridges, poorly-drained sites.
Altitude: 0–1000 m **Annual rainfall:** 800–1600 mm
Typical local abundance: Occasional–frequent.
Vegetation: Heath e.g. with *Banksia ericifolia, Epacris microphylla, Lambertia formosa*; scrub e.g. with *Kunzea ambigua, Melaleuca nodosa*; woodland e.g. with *Eucalyptus sclerophylla, Angophora bakeri*.
Substrate: Sandy-clay or clay-loam soil on sandstone, sand or granite. Low nutrients, poorly drained.
Exposure: Full sun to light shade.

Conservation

Conservation: Widespread and probably adequately conserved. Reported from Royal NP, Sydney Harbour NP, Botany Bay NP, Ku-ring-gai Chase NP, Garigal NP.

Banksia paludosa PROTEACEAE

Life history

Growth form: A shrub to 1.5 m with many stems arising from a lignotuber, some populations are non lignotuberous. Occasionally hybridizes with *B. marginata* where they grow together.
Vegetative spread:
Longevity: More than 60 years (D. Keith pers. comm.).
Primary juvenile period:

Flowers: Golden brown, dense in a spike-like arrangement 7–13 cm long on a woody stem, pollination by mammals and birds. Inflorescences take 6–8 weeks to complete flowering; pollinator activity is needed, no self-pollination; natural pollen levels limit seed set (Whelan & Goldingay 1986). Pollinated by nectar-feeding birds and Honeybees (Goldingay & Whelan 1990), small ground-dwelling mammals, Sugar Glider (Carthew et al. 1988).

Fruit/seed: Woody capsules 9–18 mm long on a cone; winged seeds sometimes released at maturity but often held until fire. Seeds produced each year have high viability but this declines greatly by the second year of storage, mostly through insect attack (University of Wollongong 1985).
Dispersal, establishment & growth: Diaspore: seed, gravity or short distance wind-dispersed. Seedling recruitment mainly after fire (D. Keith pers. comm.), although seedling recruitment in absence of fire in non-lignotuberous populations has been noted (Hilltop Herbarium specimen).
Fire response: Stems killed, resprouts from lignotuber. Does not produce substantial flowering until the third year after fire with first seed crop in the fourth. Production of inflorescences was best in the 5 year old site and rather poor in the 14 year old site (Univ of Wollongong, 1985).
Interaction with other organisms: Fungi recovered from leaves: *Asterina systema-solare, Lineostroma banksiae* (B. Summerell pers. comm.).

Distribution

Status/origin: Native.
Botanical subregions: CC SC CT ST.
Distribution Sydney area: Woronora Plateau and Blue Mountains.
Select locations: CC: Centennial Park, Maroubra, La Perouse, Helensburgh, Maddens Plains, Bulli, Cordeaux Dam, Dapto. CT: Newnes SF, Mt Banks, Wentworth Falls, Hill Top, Mittagong, Robertson, Bundanoon, Penrose, Budderoo.

Habitat

Habitat: Escarpments, plateaus, ridge crests.
Altitude: 0–1200 m **Annual rainfall:** 900–1600 mm
Typical local abundance: Frequent.
Vegetation: Woodland e.g. with *Eucalyptus piperita, E. sieberi, E. punctata, E. sparsifolia, Corymbia gummifera, Angophora costata*; heath e.g. with *Banksia oblongifolia, Epacris microphylla, Hakea teretifolia.*
Substrate: Sandy loam on sandstone, low nutrients, well-drained.
Exposure: Full sun to light shade.

Conservation

Conservation: Probably adequately conserved. Reported in Blue Mountains NP, Nattai NP. Northern geographical limit on the Tablelands is Newnes State Forest and on the coast is Centennial Park–La Perouse, though now extinct there.

Banksia robur PROTEACEAE

Life history

Growth form: Shrub about 1m high with several stems arising from a lignotuber. Hybridizes with *B. oblongifolia.*
Vegetative spread: No.
Longevity: More than 60 years (D. Keith pers. comm.).
Primary juvenile period:
Flowers: Greenish, dense in a spike-like arrangement 10–17 cm long on a woody stem, at any time of year, peaks December–January, May–July. Number of flowers per inforescence 2676 ± 704 (Clifford 1993).
Fruit/seed: Woody capsules 10–16 mm long on a cone. Up to 100 capsules, sometimes more, retained as canopy-stored seedbank (George 1981). Winged seeds released following fire, germination 22 days (Cavanagh 1974). 44 % plants were seed-sterile in a SE Queensland populaton (Clifford 1993).
Dispersal, establishment & growth: Diaspore: seed, gravity or short distance wind-dispersed. Seedling recruitment mainly after fire (D. Keith pers. comm.).
Fire response: Stems killed, resprouts from lignotuber, secondary juvenile period 2 years; limited spontaneous seed release during the interfire period (Keith 1991).
Interaction with other organisms: Fungi recovered from leaves: *Asteria sysema-solare, Trichopeltis* sp. (B. Summerell pers. comm.).

Distribution

Status/origin: Native.
Botanical subregions: NC CC; Qld.
Distribution Sydney area: Coast, north from Wollongong.
Select locations: CC: Tuggerah, Kariong, Wondabyne, Manly, Rose Bay, Botany Swamp, Kurnell, Waterfall, Stanwell Tops, Darkes Forest, Cordeaux Dam.

Habitat

Habitat: Permanently damp sites on plateaus.
Altitude: 0–500 m **Annual rainfall:** 1200–800 mm
Typical local abundance: Frequent.
Vegetation: Wet heath and sedgeland e.g. with *Sprengelia incarnata, Gleichenia dicarpa, Leptocarpus tenax.*
Substrate: Sandy or peaty swamps on Hawkesbury Sandstone or sand dunes, low nutrients.
Exposure: Full sun.

Conservation

Conservation: Wollongong is the southern geographical limit. Reported in Brisbane Water NP, Ku-ring-gai Chase NP, Sydney Harbour NP. Not conserved in Garigal NP although one population is close to the boundary; vulnerable in bushland edges near development where it is easily out-competed by regrowth of weeds after fire (e.g. now extinct at Forestville Park, L.McD.).

Banksia serrata PROTEACEAE

Life history

Growth form: Tree or large shrub to 10 m high, usually with one main stem and warty bark; leaves are toothed, 5–20 cm long.
Vegetative spread: No.
Longevity: 100 years.
Primary juvenile period: More than 9 years (Benson 1985).
Flowers: Creamy grey, dense in a spike-like arrangement 7–15 cm long on a woody stem, November–May, peak December. New Holland and White-cheeked Honeyeaters feed on nectar (Armstrong 1991), Bell Minor *Manorina melanophrys*, White-cheeked Honeyeater *Phylidonyris nigra* feed on flowers (Barker & Vestjens 1990). Native bees, ants, and Rainbow Lorikeet *Trichoglossus haematodus* fed on nectar and/or pollen (P. Kubiak pers. comm.). Blossoms eaten by Grey-headed Flying Fox *Pteropus poliocephalus* and Little Red Flying Fox *Pteropus scapulatus* (Eby 1995), Common Blossum Bat *Syconycteris australis* (Law 1994).

Fruit/seed: Woody capsules 25–35 mm long on a cone, forming a canopy-stored seedbank; winged seeds released following fire. Seed weight 77.5 mg ± 1.4; seeds dispersed up to 4 m along the ground during 1 hour with assistance of strong wind; dispersal significantly greater for release height of 2 m compared with 1 m (Hammill et al. 1998).
Dispersal, establishment & growth: Diaspore: seed, gravity or short distance wind-dispersed. Seeds germinate without treatment. Optimal temperature for germination 18–24° C, with maximum germination 60% (Sonia & Heslehurst 1978).

Fire response: Resprouts from epicormic shoots or from the lignotuber depending on severity of burn. Juvenile plants become fire-tolerant 5–7 years old; minimum lignotuber diameter required to survive a low intensity fire 4 cm, and high intensity fire 5 cm (Bradstock & Myerscough 1988). Secondary juvenile period 2–3 years (Bradstock & Auld 1987), about 3.5 years after high intensity fire 1/94 (at Lane Cove, P. Kubiak pers. comm.).
Interaction with other organisms: Host to Cup Moth larvae *Mecytha fasciata* (Common 1990), Banksia Web-covering Borer *Xylorycta strigata* and Banksia Borer *Cyria imperialis* (Elliot & Jones 1986). Larvae of moth *Xylorycta strigata* tunnel in the branches and feed on leaves (CSIRO 1991). Host to Cerambycid longicorn beetle *Paroplites australis* (Hawkeswood 1992b). Fungi recovered from leaves: *Asteria systema-solare, Elsinoe banksiae* (causing scab disease), *Lineostroma banksiae, Phomopsis* sp., *Tetraploa* sp., *Vizella banksiae; Cephaleuros birescens* causes algal leaf spot (B. Summerell pers. comm.).

Distribution

Status/origin: Native.
Botanical subregions: NC **CC** SC **CT**; Qld, Vic., Tas.
Distribution Sydney area: Widespread on coast and Upper Blue Mountains.
Select locations: **CC**: Howes Valley, Agnes Banks, Cowan, Cheltenham, Frenchs Forest, Curl Curl, Centennial Park, Kurnell, Grose Vale, Burragorang Lookout, Nepean Dam. **CT**: Newnes SF, Mt Wilson, Mt Tomah, Blackheath, Robertson.

Habitat

Habitat: Heath and woodland on sandstones and hind-dunes.
Altitude: 0–1000 m **Annual rainfall:** 800–1400 mm
Typical local abundance: Frequent.
Vegetation: Woodland e.g. with *Corymbia eximia, C. gummifera, Eucalyptus sieberi, E. agglomerata, E. piperita*, with sclerophyll shrub understorey.
Substrate: Sandy soil on sandstone, dune sand, low nutrients, well-drained.
Exposure: Full sun to light shade.

Conservation

Conservation: Probably adequately conserved. Reported in Bouddi NP, Brisbane Water NP, Marramarra NP, Muogamarra Nature Reserve, Ku-ring-gai Chase NP, Dalrymple Hay NR, Garigal NP, Lane Cove NP, Sydney Harbour NP, Royal NP, Blue Mountains NP, Gardens of Stone NP.

Banksia spinulosa var. *collina* PROTEACEAE

Life history

Growth form: Multistemmed shrub to 3 m high, with lignotuber. Two varieties are recognised but some populations do not readily fit the descriptions.
Vegetative spread: No.
Longevity:
Primary juvenile period:
Flowers: Yellow or golden, dense in a spike-like arrangement 6–15 cm long, April–September. Flower spike produced at end of shoots more than 3 years old (Blake 1971). Important source of nectar for honeyeaters in heathland (Pyke et al. 1993).
Fruit/seed: Woody capsules 10–24 mm long on a cone as canopy-stored seedbank; winged seeds released following fire.
Dispersal, establishment & growth: Diaspore: seed, gravity or short distance wind-dispersed.
Fire response: Stems killed, resprouts from lignotuber.
Interaction with other organisms: Crimson Rosella *Platycercus elegans* and Yellow-tailed Black Cockatoo *Calyptorhynchus funercus* damage inflorescences (McFarland 1985).

Distribution

Status/origin: Native.
Botanical subregions: NC CC NT CT; Qld.
Distribution Sydney area: North from Broken Bay.
Select locations: CC: Mellong Range, Morisset, Tuggerah, Somersby, Gosford. CT: Mt Wilson.

Habitat

Habitat:
Altitude: 0–1100 m **Annual rainfall:** 1000–1400 mm
Typical local abundance: Frequent.
Vegetation: Heath and woodland.
Substrate: Sandy soil on sandstone, low nutrients.
Exposure:

Conservation

Conservation: Hawkesbury River is southern geographical limit. Reported in Bouddi NP. Conservation status unknown.

Banksia spinulosa var. *spinulosa* PROTEACEAE

Life history

Growth form: Multistemmed shrub to 3 m high, with a lignotuber. Clinal change to *B. spinulosa* var. *collina* between Sydney and Newcastle.
Vegetative spread: No.
Longevity: 50–100 years.
Primary juvenile period:
Flowers: Yellow or golden, dense in a spike-like arrangement 6–15 cm long. Inflorescences with up to 1000 flowers; individuals may not flower every year (Carthow 1993). Buds open from top of the spike, downwards (Blake 1971). Inflorescences take 6–8 weeks to finish flowering; more flowers may be open during the day than during night; pollinator activity is needed, no self-pollination; pollen levels do not limit seed set (Whelan & Goldingay 1986). Pollinated by mammals and birds; visited by Sugar Glider *Petaurus breviceps*, Eastern Pygmy Possum *Cerartetus nanus*, Brown Antechinus *Antechinus stuartii*, Eastern Spinebill *Acanthorhynchus tenuirostris*, Honeybee *Apis mellifera* and several species of moths; mammals are more effective pollinators than Eastern Spinebills and insects (Carthew 1993b). Important source of nectar for honeyeaters in heathland (Pyke et al. 1993). Flowers visited by Honeybees, 3–4 species of native bees feeding on pollen and nectar; flies, 2 species of ants and birds Eastern Spinebill *Acanthorhynchus tenuirostris*, Noisy Miner *Manorina melanocephala* fed on nectar (P. Kubiak pers. comm.).
Fruit/seed: Woody capsules 10–24 mm long on a cone as canopy-stored seedbank; winged seeds weigh 8–15 mg, released following fire, or rarely, spontaneously (George 1981).
Dispersal, establishment & growth: Diaspore: seed, gravity or short distance wind-dispersed. Seeds germinate readily, without treatment.
Fire response: Resprouts from lignotuber, secondary juvenile period 3 years. Following spring fire more than 10% seeds germinated, survival of seedlings for next 1.5 years 5% (Whelan & Tait 1995).
Interaction with other organisms: Fungi recovered from leaves: *Asterina systema-solare*, *Cooksonomyces banksiae*, *Periconiella banksiae* (B. Summerell pers. comm.).

Distribution

Status/origin: Native.
Botanical subregions: **CC** SC **CT** ST; Qld.
Distribution Sydney area: Coast and adjacent plateaus south of Hawkesbury River, and Blue Mountains.
Select locations: **CC**: Duffys Forest, Hornsby, Epping, Agnes Banks, Springwood, Kogarah, Condell Park, Nortons Basin, Maddens Plain, Kangaroo Valley. **CT**: Newnes Plateau, Mt Banks, Kurrajong Heights, Wentworth Falls, Kanangra Walls, Kowmung River, Carrington Falls, Fitzroy Falls, Penrose SF.

Habitat

Habitat: Sandstone plateaus.
Altitude: 0–1200 m **Annual rainfall:** 700–1400 mm
Typical local abundance: Frequent.
Vegetation: Woodland e.g. with *Eucalyptus haemastoma*, *E. sieberi*, *E. punctata*, *E. piperita*, *E. sclerophylla*, *Angophora bakeri*, *Corymbia gummifera*, *E. parramattensis*, *Melaleuca decora*; heath e.g. with *Angophora hispida*, *Petrophile sessilis*, *Hakea sericea*.
Substrate: Generally deep sandy clay soils on sandstone, granite, shale, low nutrients, with periodic water logging.
Exposure: Full sun, shading by other shrubs appears to cause deterioration and lack of flowering.

Conservation

Conservation: Probably adequately conserved. Marramarra NP, Muogamarra Nature Reserve, Ku-ring-gai Chase NP, Garigal NP, Dalrymple Hay Nature Reserve, Lane Cove NP, Sydney Harbour NP.

Conospermum ellipticum PROTEACEAE

Life history

Growth form: Erect shrub 50–80 cm high. Intermediate forms between *Conospermum ellipticum* and *C. taxifolium* found growing in same areas.
Vegetative spread:
Longevity: 25–60 years (D. Keith pers. comm.).
Primary juvenile period:
Flowers: Cream to white, tubular.
Fruit/seed: Hairy nut 2–3 mm long, with ring of hairs probably serving positional function in soil (B. Rice pers. comm.), weight 2 mg, shed at maturity.
Dispersal, establishment & growth: Diaspore: nut. No special morphology for dispersal (Westoby et al 1990). Soil-stored seedbank, recruitment mainly after fire (D. Keith pers. comm.).
Fire response: Resprouts from subterranean buds (D. Keith pers. comm.).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CC SC.
Distribution Sydney area: Mainly coastal.
Select locations: CC: Bouddi NP, Cape Solander, Loftus, Bulli.

Habitat

Habitat: Restricted to wet heaths (Morrison et al. 1994).
Altitude: 0–100 m **Annual rainfall:** 1200–1400 mm
Typical local abundance: Occasional to frequent.
Vegetation: Wet heath e.g. with *Allocasuarina distyla, Leptospermum* sp., *Lasiopetalum* sp., *Banksia serrata*.
Substrate: Shallow sandy soil on sandstone, low nutrients, poorly-drained.
Exposure: Full sun.

Conservation

Conservation: Reported from Bouddi NP (the northern geographical limit), Royal NP.

Conospermum ericifolium PROTEACEAE

Life history

Growth form: Erect shrub 50–80 cm high Intermediate forms between *Conospermum ericifolium* and *C. taxifolium* found growing in same areas.
Vegetative spread: No.
Longevity:
Primary juvenile period: Less than 2 years (P. Kubiak pers. comm.).
Flowers: Cream to white, tubular, spring. Peak flowering 4–5 years after high intensity fire 1/94; flowers visited for nectar by Honeybees, two species of native bees, 4 species of beetles, bugs and moths (P. Kubiak pers. comm.).
Fruit/seed: Hairy nut 2–3 mm long, with ring of hairs probably serving positional function in soil (B. Rice pers. comm.), weight 2 mg, shed at maturity.
Dispersal, establishment & growth: Diaspore: nut. No special morphology for dispersal (Westoby et al. 1990).
Fire response: Killed after high intensity fire 1/94 (at Narrabeen Lake, P. Kubiak pers. comm.).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CC SC.
Distribution Sydney area: Mainly coastal, Toukley to Port Jackson.
Select locations: CC: Girrakool, Bouddi NP, Maroota.

Habitat

Habitat: Plateaus.
Altitude: 0–150 m **Annual rainfall:** 900–1200 mm
Typical local abundance: Occasional to frequent.
Vegetation: Heath and shrubby woodland e.g. with *Corymbia gummifera, Eucalyptus haemastoma, Angophora hispida, Banksia serrata, B. ericifolia, Angophora hispida, Boronia ledifolia, Grevillea buxifolia, Hakea propinqua.*
Substrate: Shallow sandy soil on sandstone, low nutrients, periodically poorly-drained.
Exposure: Full sun to light shade.

Conservation

Conservation: Conservation adequacy unknown, Kariong is northern geographical limit. Reported in Bouddi NP, Brisbane Water NP. Vulnerable in Western Sydney (James et al. 1999).

Conospermum longifolium subsp. *angustifolium* PROTEACEAE

Life history

Growth form: Undershrub or shrub to 2 m high, finely hairy.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Cream to white, tubular, July–October peak September.
Fruit/seed: Hairy nut 2–3 mm long, December. Probably shed at maturity (P. Myerscough pers. comm.).
Dispersal, establishment & growth: Diaspore: nut.
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CC.
Distribution Sydney area: Lower Georges River–Waterfall–Appin.
Select locations: CC: Canterbury, Deadmans Creek, Como, Engadine, Audley, Wedderburn, Picton.

Habitat

Habitat: Stony ridges or upper slopes.
Altitude: 0–200 m **Annual rainfall:** 900–1200 mm
Typical local abundance: Frequent–occasional.
Vegetation: Woodland e.g. with *Persoonia pinifolia, Hakea sericea, Kunzea ambigua*; heath e.g. with *Banksia ericifolia, Petrophile pulchella, Acacia myrtifolia, Grevillea sericea.*
Substrate: Sandy soils, sandy clay or laterite gravel over sandstone, low nutrients.
Exposure: Full sun to light shade.

Conservation

Conservation: Local endemic, restricted to Lower Georges River–Waterfall–Appin (Harden 2000). Conservation status unknown. Reported in Royal NP.

Conospermum longifolium subsp. *longifolium* PROTEACEAE

Life history

Growth form: Undershrub or shrub to 2 m high, finely hairy.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Cream to white, tubular, June–October, peak September. Possibly pollinated by beetles, flies, native bees, and bugs (P. Kubiak pers. comm.).
Fruit/seed: Hairy nut 2–3 mm long, with ring of hairs probably serving positional function in soil (B. Rice pers. comm.), weight 5 mg. Probably shed at maturity (P. Myerscough pers. comm.), September–October.
Dispersal, establishment & growth: Diaspore: nut. No special morphology for dispersal (Westoby et al. 1990).
Fire response: Resprouts from ground level or below (at Bantry Bay after high intensity fire 12/1990, L.McD.). Secondary juvenile period less than 1 year after high intensity fire 1/94 (at Narrabeen Lake, P. Kubiak pers. comm.).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CC SC CT CWS.
Distribution Sydney area: Mainly Newcastle–Port Jackson.
Select locations: CC: Wollombi, Wisemans Ferry, Cowan, Ingleside, Belrose, Manly. CT: Cambewarra.

Habitat

Habitat: Stony ridges or slopes.
Altitude: 0–200 m **Annual rainfall:** 800–1400 mm
Typical local abundance: Frequent.
Vegetation: Open-forest and woodland e.g. with *Corymbia gummifera, Eucalyptus oblonga, E. sieberi, Allocasuarina torulosa, Xylomelum pyriforme*; scrub e.g. with *Angophora hispida*; heath.
Substrate: Sandy soils, low nutrients.
Exposure: Full sun to light shade.

Conservation

Conservation: Conservation status unknown. Reported in Ku-ring-gai Chase NP.

Conospermum longifolium subsp. *mediale* PROTEACEAE

Life history

Growth form: Undershrub or shrub to 2 m high, finely hairy.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Cream to white, tubular, August–February, peak December.
Fruit/seed: Hairy nut 2–3 mm long, December. Probably shed at maturity (P. Myerscough pers. comm.).
Dispersal, establishment & growth: Diaspore: nut.
Fire response:
Interaction with other organisms: A fungus *Mycosphaerella* sp. has been recovered form leaf spots (B. Summerell pers. comm.).

Distribution

Status/origin: Native.
Botanical subregions: CC SC CT.
Distribution Sydney area: Mainly Blue Mountains.
Select locations: CC: Putty, Berambing, Springwood, Glenbrook, Buxton, Cambewarra. CT: Hill Top, Robertson, Belanglo.

Habitat

Habitat: Rocky ridgetops or upper slopes.
Altitude: 200–600 m **Annual rainfall:** 700–1600 mm
Typical local abundance: Rare–occasional.
Vegetation: Open-forest e.g. with *Corymbia eximia, C. gummifera, E. sieberi, E. sclerophylla, E. piperita, E. globoidea* and shrubby understorey — *Lambertia formosa, Persoonia levis, P. linearis, Hakea sericea, Banksia serrata, Grevillea arenaria, G. buxifolia.*
Substrate: Sandy, stoney soil over sandstone, low nutients, well-drained.
Exposure:

Conservation

Conservation: Conservation status unknown. Reported in Blue Mountains NP.

Conospermum taxifolium PROTEACEAE

Life history

Growth form: Erect shrub 50–80 cm high. Hybrids with *C. ericifolium* or *C. ellipticum* occur rarely where there are intermediate habitats (Morrison et al. 1994).
Vegetative spread: No.
Longevity: 25–60 years (D. Keith pers. comm.).
Primary juvenile period: 4 years (Benson 1985, D. Keith pers. comm.).
Flowers: Cream to greyish white, tubular, August–January, peak September. Insect-pollinated.
Fruit/seed: Hairy nut 2–3 mm long, weight 1.4 mg, shed at maturity.
Dispersal, establishment & growth: Diaspore: nut. Seeds with 100% dormancy, persistent soil-stored seedbank, estimated half-life 2 yrs (Auld et al. 2000). Recruitment mainly after fire (D. Keith pers. comm.). A vigorous coloniser species on deep sand at Agnes Banks.
Fire response: Resprouted vigorously after high intensity fire at Mellong, and upper Blue Mountains. Resprouts (D. Keith pers. comm.). Killed by fire and re-establishes from soil-stored seed though some capable of resprouting from base of stem (depending on fire intensity?) (M. Fox pers. comm.).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC CC SC NT CT ST CWS NWP; Qld, Vic.
Distribution Sydney area: Widespread, coast and Blue Mountains.
Select locations: CC: Ku-ring-gai Chase NP, Agnes Banks, La Perouse, Wattamolla, Helensburgh, Bargo. CT: Newnes Plateau, Mount Hay, Wentworth Falls, Hill Top, Mittagong.

Habitat

Habitat: Coastal headlands, ridgetops, shallow valleys.
Altitude: 0–1200 m **Annual rainfall:** 800–1400 mm
Typical local abundance: Frequent–occasional.
Vegetation: Coastal heath e.g. with *Westringia fruticosa, Melaleuca armillaris*; montane heath e.g. with *Allocasuarina nana, Eucalyptus apiculata*; woodland e.g. with *Eucalyptus sclerophylla, E. piperita, E. sieberi, E. sparsifolia.*
Substrate: Shallow sandy soils on sandstone and old dunes, low nutrients.
Exposure: Exposed to mountain and sea winds, full sun.

Conservation

Conservation: Reported in Bouddi NP, Brisbane Water NP, Ku-ring-gai Chase NP, Garigal NP, Lane Cove NP, Sydney Harbour NP, Blue Mountains NP.

Conospermum tenuifolium PROTEACEAE

Life history

Growth form: Spreading shrub to 30 cm high and up to 4 m across, with stems rising from a woody base, forming tangled grass-like masses. Leaves long, narrow, curly and wiry.
Vegetative spread: No.
Longevity:
Primary juvenile period:
Flowers: Bluish or lilac or pinkish-white, tubular, September–January, peak October. Insect-pollinated.
Fruit/seed: Hairy nut 2–3 mm long, October–November. Probably shed at maturity (P. Myerscough pers. comm.).
Dispersal, establishment & growth: Diaspore: nut.
Fire response: Resprouts (at Leura).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CC SC CT.
Distribution Sydney area: Widespread in Blue Mountains, scattered on coast.
Select locations: CC: Mangrove Mountain, Manly, Botany Swamp, Waterfall, Darkes Forest, Bulli, Bargo, Cambewarra. CT: Mount Coricudgy, Blackheath, Katoomba, Wentworth Falls, Moss Vale, Fitzroy Falls.

Habitat

Habitat: Ridgetops, slopes, creekbanks.
Altitude: 0–1000 m **Annual rainfall:** 900–1400 mm
Typical local abundance: Frequent–occasional.
Vegetation: Heath, woodland and open-forest e.g. with *Eucalyptus sieberi, E. piperita, E. sclerophylla, Corymbia gummifera.*
Substrate: Sandy soil over sandstone, low nutrients, sometimes moist, soaks.
Exposure:

Conservation

Conservation: Rare and probably inadequately conserved in Gosford area, rare in Ku-ring-gai Chase NP. Reported in Brisbane Water NP.

Grevillea acanthifolia subsp. *acanthifolia* PROTEACEAE

Life history

Growth form: Shrub to 1–1.5 m high, with divided leaves, most closely related to *G. rivularis*; hybridises naturally with *G. laurifolia* (Makinson 2000) to form *G.* x *gaudichaudii* (R. Makinson pers. comm.).
Vegetative spread: No.
Longevity:
Primary juvenile period:
Flowers: Silver to reddish grey, mauve-pink to red, September–May, peak October–January.
Fruit/seed: Hairy capsule 9–11 mm long, with reddish brown stripes or blotches and 1–2 winged seed, released at maturity. Likely to have a food body for ant-dispersal (J. Howell pers. comm.).
Dispersal, establishment & growth: Diaspore: seed, recruitment mainly after fire. Seedling density under fire-killed plants 9-25 per m^2 (at Lithgow).
Fire response: Resprouts in wettest situations but killed elsewhere e.g. 60% mortality recorded at Lithgow. Re-establish from soil-stored seed.
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CT.
Distribution Sydney area: Upper Blue Mountains.
Select locations: CT: Lithgow, Bell, Blackheath, Katoomba, Wentworth Falls.

Habitat

Habitat: Swampy areas or wet rock shelves, or on stream banks.
Altitude: 900–1100 m **Annual rainfall:** 900–1400 mm
Typical local abundance: Frequent.
Vegetation: Swampy heath e.g. with *Leptospermum lanigerum, L. myrtifolium, Gahnia filifolia, G. subequaeglumis, Baumea rubiginosa, B. acuta, Xyris gracilis, Lepyrodia scariosa, L. anarthria.*
Substrate: Sand or peat on sandstone, low nutrients, impeded drainage.
Exposure: Full sun.

Conservation

Conservation: Local endemic, conservation status unknown.

Grevillea arenaria subsp. *arenaria* PROTEACEAE

Life history

Growth form: Single-trunked shrub 1–4 m high, with simple leaves; there are two forms: silky form from Bents Basin to Yerranderie and villous form south from Wombeyan Caves; may occasionally hybridize with *G. rosmarinifolia, G. lanigera, G. mucronulata* (Makinson 2000).
Vegetative spread: No.
Longevity:
Primary juvenile period:
Flowers: Red, pink or orange, often green or yellow at base, all months but mainly August–November. July–November, mainly bird-pollinated (Makinson 2000).
Fruit/seed: Hairy, ribbed capsule 12–22 mm long, with 1–2 winged seed, released at maturity.
Dispersal, establishment & growth: Diaspore: seed. Likely to have a food body for ant-dispersal (J. Howell pers. comm.).
Fire response: Killed, regenerates from soil-stored seed (Makinson 2000).
Interaction with other organisms: Flowers eaten by Crimson Rosella *Platycercus elegans* (Lepschi 1993).

Distribution

Status/origin: Native.
Botanical subregions: CC SC ST.
Distribution Sydney area: Widespread.
Select locations: CC: Yarramundi, Nepean Dam, Nattai. CT: Wombeyan Caves, Barbers Creek.

Habitat

Habitat: Near creeks or cliffs, rocky hillsides.
Altitude: 0–900 m **Annual rainfall:** 800–1200 mm
Typical local abundance: Frequent.
Vegetation: Open woodland; shrubland e.g. with *Acacia chalkeri.*
Substrate: Gravelly loam, dark clay loam, on granite, limestone or alluvium; on limestone at Wombeyan Caves.
Exposure: Full sun to light shade.

Conservation

Conservation: Conservation status unknown.

Grevillea arenaria subsp. *canescens* PROTEACEAE

Life history

Growth form: Single-trunked shrub 1–3 m high, or suckering shrub to 1 m high ; leaves velvety on lower surface.
Vegetative spread: Occasional suckering.
Longevity:
Primary juvenile period:
Flowers: Red, pink or orange, often green or yellow at base, all months but mainly August–November. Mainly bird-pollinated (Makinson 2000).
Fruit/seed: Hairy, ribbed capsule 12–22 mm long, with 1-2 winged seed released at maturity.
Dispersal, establishment & growth: Diaspore: seed, soil-stored seedbank. Likely to have a food body for ant-dispersal (J. Howell pers. comm.).
Fire response: Mostly killed, regenerates from soil-stored seed; sometimes resprouts from rhizomes (Makinson 2000).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: **CT** ST NWS CWS NWP.
Distribution Sydney area: Western Blue Mountains.
Select locations: **CT**: Rylstone, Winburndale, Bathurst, Glen Davis, Mt Cookem, Blackheath, Jenolan Caves, Kanangra, Kowmung River, Abercrombie River, .

Habitat

Habitat: Steep slopes, rocky areas.
Altitude: 700–1000 m **Annual rainfall:** 600–1200 mm
Typical local abundance: Occasional–frequent.
Vegetation: Woodland e.g. with *Eucalyptus blakelyi, E. rossi, E. polyanthemos, E. punctata.*
Substrate: Dry clayey or gravelly clay soil, sandy soils on conglomerate, granite, Devonian quartzite, basalt.
Exposure:

Conservation

Conservation: Conservation status unknown.

Grevillea aspleniifolia PROTEACEAE

Life history

Growth form: Spreading shrub 1–5 m high, to 4 m across, with hairy branchlets and long narrow leaves which are often serrated. Sometimes confused with *G. longifolia* (Makinson 2000).
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Pinkish to purplish, mainly September–March. July–November (Makinson 2000).
Fruit/seed: Hairy capsule with reddish brown stipes or blotches, with one deeply wrinkled, 1–2 winged seeds (McGillivray & Makinson 1993), released at maturity.
Dispersal, establishment & growth: Diaspore: seed, wind-dispersed locally. Likely to have a food body for ant-dispersal (J. Howell pers. comm.).
Fire response: Mostly killed (R. Makinson pers. comm.).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CC CT ST.
Distribution Sydney area: Warragamba and Nattai catchments.
Select locations: CC: Kedumba Valley, Burragorang Valley, Nattai River, Warragamba, Picton, Yerranderie. CT: Hill Top.

Habitat

Habitat: Open, rocky sites on ridges, or moist sites near streams.
Altitude: 0–500 m **Annual rainfall:** 800–900 mm
Typical local abundance: Rare to frequent.
Vegetation: Open-forest e.g. with *Eucalyptus sclerophylla, E. piperita, E. agglomeratea, Angophora costata*; woodland e.g. with *Eucalyptus punctata, E. eugenioides, E. fibrosa, Allocasuarina stricta*; moist situations e.g. with *Casuarina cunninghamiana, Prostanthera incana.*
Substrate: Shallow sandy soil or sandy loam on sandstone or shale, low nutrients, well-drained.
Exposure: Medium shade to full sun.

Conservation

Conservation: Reported from Blue Mountains NP, Nattai NP, conservation status unknown.

Grevillea baueri subsp. *baueri* PROTEACEAE

Life history

Growth form: Low bushy shrub to 1 m high.
Vegetative spread: No.
Longevity:
Primary juvenile period:
Flowers: Red to pink with cream or yellow, July–November, mainly bird-pollinated (Makinson 2000).
Fruit/seed: Hairy capsule 14 mm long, 1–2 seed released at maturity.
Dispersal, establishment & growth: Diaspore: seed, gravity-dispersed. Likely to have a food body for ant-dispersal (J. Howell pers. comm.).
Fire response: Killed, regenerates from soil-stored seed (Makinson 2000).
Interaction with other organisms: Grazed by stock (Herbarium record).

Distribution

Status/origin: Native.
Botanical subregions: CC SC CT.
Distribution Sydney area: Camden–Picton–Mittagong area.
Select locations: CC: Appin, Buxton. CT: Hill Top, Aylmerton, Mittagong, Berrima, Belanglo SF, Wombeyan Caves.

Habitat

Habitat: Roadside, hillsides.
Altitude: 500–900 m **Annual rainfall:** 800–1000 mm
Typical local abundance: Frequent–occasional.

Vegetation: Open forest e.g. with *Eucalyptus macarthurii, E. radiata, Banksia marginata, Hakea dactyloides, Lomatia ilicifolia*; open-woodland e.g. with *Eucalyptus sieberi*; scrubland.
Substrate: Sandy soils on sandstone, low nutrients.
Exposure:

Conservation

Conservation: Appin is the northern geographical limit

Grevillea buxifolia subsp. ***buxifolia*** **PROTEACEAE**

Grey Spider Flower

Life history

Growth form: Shrub 1-2 m high.
Vegetative spread: No.
Longevity: 10–20 years.
Primary juvenile period: 8 years (Benson 1985), about 2 years after high intensity fire 1/94 (at Lane Cove, P. Kubiak pers. comm.).
Flowers: Rusty brown to faun, mainly July–November, sporadic in other months (Makinson 2000). May be pollinated by large native bees seeking nectar and possibly smaller ones gathering pollen (P. Kubiak pers. comm.). Peak flowering 4–5 years after high intensity fire 1/94.
Fruit/seed: Hairy capsule 18–22 mm long (Makinson 2000), with 1–2 seeds; seed weight 62.5 mg ±3.1 (Morris 2000), 53 mg (Auld & Denham 1999), weight 50–75 mg, seed with an elaiosome (lipid body)(Auld 1995, Westoby et al. 1990), released at maturity, January–March.

Dispersal, establishment & growth: Diaspore: seed, with food body ant-adapted for dispersal (Westoby et al. 1990, Rice & Westoby 1981). Small ants *Iridomyrmex, Pheidole* sp., *Crematogaster* sp. individuals working together move seed up to 20 cm and remove the elaiosome in pieces, or large solitary ants *Aphaenogaster* sp., *Thytidophonera* sp. may drag the seeds to their nests; thus, up to 20% of seed may escape predation by native mammals e.g. Bush Rat *Rattus fuscipes*, Swamp Wallaby *Wallabia bicolor* (Auld 1995). Strongly pulsed pattern of post-fire germination; no breaking of seed dormancy by heating (Auld & Tozer 1995).

Germination experiment showed that: untreated seeds did not germinate; germination mostly 30–40 days after treatment; smoke treatment increased amount of germination (40%); heat treatment alone induced 10–13% germination; smoke treatment plus heat treatment resulted in at least 60% germination; scarification of unsmoked, heat-treated seed increased germination; water uptake occurred rapidly in both scarified and unscarified seeds, mostly within 24 hrs and water loss was equally rapid on drying (Morris 2000), heat effect increased in presence of smoke and smoke effect increased in presence of heat, with smoke having the most influence (Kenny 2000).

Fire response: Killed and re-establishes from soil-stored seed.
Interaction with other organisms: Shoot damage by rabbits but not eaten (P. Kubiak pers. comm.). Fungus *Placoasterella baileyi* causes leaf spot (B. Summerell pers. comm.). Pre-dispersal seed predation more than 30% by weevils *Cydmaea dorsalis* (Auld & Denham 2001b).

Distribution

Status/origin: Native.
Botanical subregions: CC SC CT.
Distribution Sydney area: Coast and adjacent plateaus.
Select locations: CC: Putty, Mt Yengo, Somersby, Cowan, Berowra, Kenthurst, Galston, Cheltenham, St Ives, Belrose, Frenchs Forest, Manly, Como, Waterfall, Appin, Springwood.

Habitat

Habitat: Ridges, slopes.
Altitude: 0–400 m **Annual rainfall:** 900–1400 mm
Typical local abundance: Occasional–frequent.
Vegetation: Woodland e.g. with *Eucalyptus haemastoma, E. sieberi, Corymbia gummifera, Angophora bakeri, Banksia oblongifolia, B. serrata*; heath e.g. with *Banksia ericifolia, Grevillea linearifolia, G. sericea, Persoonia levis, Leptospermum trinervium.*
Substrate: Skeletal sandy soils over sandstone, low nutrients, well-drained.
Exposure:

Conservation

Conservation: Probably adequately conserved. Reported in Brisbane Water NP, Marramarra NP, Ku-ring-gai Chase NP, Garigal NP, Lane Cove NP, Sydney Harbour NP, Royal National Park.

Grevillea buxifolia subsp. *ecorniculata* PROTEACEAE

Life history

Growth form: Shrub 1-2 m high, with simple leaves.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Grey, mainly July–November, insect-pollinated (Makinson 2000).
Fruit/seed: Hairy capsule 18–22 mm long, with 1–2 seeds, released at maturity. Seed with food body (J. Howell pers. comm.)
Dispersal, establishment & growth: Diaspore: seed, with a short waxy elaiosome (Makinson 2000), ant-dispersed locally (J. Howell pers. comm.).
Fire response: Probably killed, regenerates from soil-stored seed (Makinson 2000).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CC.
Distribution Sydney area: Putty–Gospers Mountain–Wollombi.
Select locations: CC: Putty, Mt Yengo, Mt White, Wollombi.

Habitat

Habitat: Ridges, upper slopes.
Altitude: 0–700 m **Annual rainfall:** 1000–1400 mm
Typical local abundance: Frequent.
Vegetation: Open-forest with shrubby understorey e.g. with *Astrotricha* sp., *Coopernookia barbata, Persoonia levis, Leptospermum trinervium.*
Substrate: Skeletal sandy soils over sandstone, low nutrients.
Exposure:

Conservation

Conservation: Local endemic, confined to area between Putty, Gospers Mountain and Wollombi, conservation status unknown.

Grevillea caleyi PROTEACEAE

Life history

Growth form: Open spreading shrub usually 1–4 m high, hairy branchlets, deeply divided leaves, and reddish, hairy young foliage.
Vegetative spread: No.
Longevity: Some plants may live 20–30 years but high mortality in populations 12–15 years after fire (Auld et al. 1991).
Primary juvenile period: 2–4 years (Auld & Denham 2001a).
Flowers: Red, mainly July–February. Most likely pollinators are honeyeaters: New Holland, White Cheeked, White Eared, Little Wattlebirds and Eastern Spinebills; may also be self-compatible (Scott et al. 1995).
Fruit/seed: Hairy capsule 17–21 mm long, with reddish brown stripes or blotches, mature summer, 1 (rarely 2) seeds released at maturity with limited dispersal beneath parent at maturity; seeds without wings. Seeds without an elaiosome (Auld 1995). Seeds heavy (the largest of all *Grevillea* species) (McCormack & O'Neil 1993), weight 318–351 mg (Auld & Denham 2001b.)

Dispersal, establishment & growth: Diaspore: seed, gravity-dispersed at maturity. No known dispersal agents; seed viability is high 69–95%, dormancy 93%, and buried seed with seasonal secondary dormancy is relatively long-lived (Auld et al. 2000), estimated half-life 6–10 years, but with combined effects of pre- and post-dispersal predation very little seed is added to the soil-stored seedbank for at least 4–6 years after fire (Auld et al. 2000, Scott et al. 1995, Auld & Denham 2001a,b). Hard-coated seed, germinates after heat and mechanical damage, though responds poorly after control burns (Scott 1986). Seed production generally increases up to 8–10 years and declines after 10–15 years (Auld & Denham 2001a).

Fire response: Killed and re-establish from soil-stored seed. Responds best to high intensity fire. Requires minimum fire-free period 8–12 years for conservation; areas unburnt 20–25 years need monitoring — if adults have died and there is no seedling recruitment, consideration should be given to burning (Auld & Scott 1996).

Interaction with other organisms: Predispersal seed predators are weevils *Cydmaea dorsalis* (12–26% loss) and probably parrots (Auld, Bradstock & Keith 1991, Auld & Denham 2001b); seed predation post-dispersal 82–100%, 91–100% from 2–5 years after fire, mostly by Bush Rat *Rattus fuscipes* (35–68% seed loss) and Swamp Wallaby *Wallabia bicolor* (31–65% seed loss) (Auld & Denham 2001a, Scott et al. 1995), known to suffer high levels of seed losses to native mammals in areas unburnt for greater than 10 years (Auld & Denham 1999). Black ants feed on nectar (L.McD.)

Distribution

Status/origin: Native.
Botanical subregions: CC.
Distribution Sydney area: Terrey Hills to Belrose.
Select locations: CC: Terrey Hills, Belrose.

Habitat

Habitat: Extremely restricted, specific to lateritic sandstone ridgetops (A. Auld pers. comm.).
Altitude: 200 m **Annual rainfall:** 1200 mm
Typical local abundance: Rare–frequent.
Vegetation: Open-forest–woodland e.g. with *Eucalyptus capitellata, Corymbia gummifera, Eucalyptus sieberi* with understorey dominated by plants of Proteaceae and Fabaceae families; see Duffys Forest Community of Benson and Howell (1994).
Substrate: Residual cappings of ironstone soils — clayey soil of lateritic sandstone ridgetops.
Exposure:

Conservation

Conservation: Local endemic, listed as Endangered (Schedule 1) NSW *Threatened Species Conservation Act 1995*, coded 2ECi on national rare species list (Briggs & Leigh 1996). Endangered by road widening, too frequent burning and competition from exotic species (Scott et al. 1995). Reported in Ku-ring-gai Chase NP, Garigal NP.

Grevillea capitellata *(G. diffusa* subsp. *diffusa* 'Robust Form') **PROTEACEAE**

Life history

Growth form: Low or prostrate shrub to 0.5 m high, with simple leaves and a distinctly rusty brown hairy covering on the new growth, which distinguishes it from *G. diffusa.*
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Deep crimson to black-maroon, July–December; pollinator not known (Makinson 2000).
Fruit/seed: Capsule 18 mm long, with 1–2 seed released at maturity.
Dispersal, establishment & growth: Diaspore: seed. Likely to have a food body for ant-dispersal (J. Howell pers. comm.).
Fire response: Killed and regenerates from soil-stored seed or sometimes may possibly resprout from lignotuber or basal suckers (Makinson 2000).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CC.
Distribution Sydney area: Woronora Plateau.
Select locations: CC: Bulli, Mt Keira, Mt Ousley, Cordeaux Dam.

Habitat

Habitat:
Altitude: 0–400 m **Annual rainfall:** 1400–1600 mm
Typical local abundance: Frequent.
Vegetation: Woodland e.g. with *Eucalyptus sieberi, E. piperita, E. racemosa, Corymbia gummifera;* heath e.g. with *Banksia ericifolia, Hakea* sp., *Grevillea oleoides,* species of Restionaceae.
Substrate: Sandy soils over sandstone or pebbly ironstone.
Exposure:

Conservation

Conservation: Local endemic, restricted to plateau behind Illawarra escarpment. Conservation status unknown.

Grevillea diffusa subsp. *constablei* PROTEACEAE

Life history

Growth form: Spreading to erect shrub 1–2 m high; possible genetic influence from *G. linearifolia* or *G. sericea* (Makinson 2000).
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Dark crimson to dark burgundy. Flowers August–?November; bird- and probably also insect-pollinated (Makinson 2000).
Fruit/seed: Capsule 11–16 mm long, with 1–2 seed released at maturity.
Dispersal, establishment & growth: Diaspore: seed. Likely to have a food body for ant-dispersal (J. Howell pers. comm.).
Fire response: Probably killed (R. Makinson pers. comm.).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CC.
Distribution Sydney area: Waterfall to Helensburgh and Georges River.
Select locations: CC: Waterfall, Royal NP.

Habitat

Habitat: Woodland, often near creeks.
Altitude: 0–100 m **Annual rainfall:** 900–1400 mm
Typical local abundance:
Vegetation: Open-forest, woodland.
Substrate: Sandy loam soils.
Exposure: Shade.

Conservation

Conservation: Restricted local endemic, conservation status not known. Reported in Royal NP.

Grevillea diffusa subsp. *diffusa* PROTEACEAE

Life history

Growth form: Low dense spreading shrub ususally less than 50 cm high, with hairy branchlets; known to hybridize with *G. sericea* (Makinson 2000).
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Dark red, or rarely green and brown, July–October, peak September. Bird- and probably also insect-pollinated (Makinson 2000).
Fruit/seed: Capsule 11–16 mm long, with 1–2 seed released at maturity.
Dispersal, establishment & growth: Diaspore: seed. Likely to have a food body for ant-dispersal (J. Howell pers. comm.).
Fire response: Killed, regenerates from soil-stored seed (Makinson 2000).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CC.
Distribution Sydney area: Woronora Plateau.
Select locations: CC: Leumeah, Appin, Wedderburn, Audley, Lucas Heights, Helensburgh.

Habitat

Habitat: Low ridges and slopes (Makinson 2000).
Altitude: 0–200 m **Annual rainfall:** 1000–1600 mm
Typical local abundance: Occasional–frequent.
Vegetation: Open-forest, shrubby woodland e.g. with *Angophora costata, Eucalyptus piperita;* dry heath e.g. with *Angophora hispida.*
Substrate: Sandy to loamy soils on sandstone, low nutrients.
Exposure:

Conservation

Conservation: Restricted local endemic. Reported in Royal NP. Conservation status not known.

Grevillea diffusa subsp. ***filipendula*** PROTEACEAE

Life history

Growth form: Low spreading shrub to 1 m high. Occasionally hybridises with *G. linearifolia* (Makinson 2000).
Vegetative spread: No.
Longevity:
Primary juvenile period:
Flowers: Scarlet to light burgundy, May–October, peak July. Bird and probably also insect-pollinated (Makinson 2000).
Fruit/seed: Capsule 11–16 mm long, with 1–2 seed released at maturity, October–November; seed weight 23.5 mg ± 1.1 (Morris 2000).
Dispersal, establishment & growth: Diaspore: seed. Likely to have a food body for ant-dispersal (J. Howell pers. comm.). Germination experiment showed that: untreated seeds did not germinate; germination mostly 30–40 days after treatment; germination commenced earlier in smoked seeds; smoke treatment increased amount of germination (40%); heat treatment alone induced 10–13% germination; smoke treatment plus heat treatment resulted in at least 60% germination; water uptake occurred rapidly in both scarified and unscarified seeds, mostly within 24 hrs and water loss was equally rapid on drying (Morris 2000).
Fire response: Killed. Regenerates from soil-stored seed (Makinson 2000).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CC.
Distribution Sydney area: Gosford area.
Select locations: CC: Calga, Mt White, Mooney Mooney, Killcare.

Habitat

Habitat: Rocky sites, shallow soil.
Altitude: 0–200 m **Annual rainfall:** 1200–1400 mm
Typical local abundance: Frequent.
Vegetation: Open–forest and woodland e.g. with *Corymbia gummifera, C. eximia, Eucalyptus haemastoma, Banksia serrata;* occasionally heath e.g. with *Allocasuarina distyla.*
Substrate: Shallow sandy soils over sandstone, low nutrient soil.
Exposure:

Conservation

Conservation: Restricted local endemic, conservation status unknown.

Grevillea divaricata (*G. rosmarinifolia* var. *divaricata*) PROTEACEAE

Life history

Growth form: Low shrub to 0.4 high. Known only from the Type collection made in 1823, N of Bathurst (Harden 1991).
Vegetative spread: Herbarium specimen appears to be rhizomatous or lignotuberous and capable of stem-basal suckering (Makinson 2000).
Longevity:
Primary juvenile period:
Flowers: Colour not known, probably red, or red and cream, April and spring, primarily bird-pollinated (Makinson 2000).
Fruit/seed: Fruit and seed not known (Makinson 2000).
Dispersal, establishment & growth: Likely to have a food body for ant-dispersal (J. Howell pers. comm.).
Fire response: Not known.
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CT .
Distribution Sydney area: Bathurst.
Select locations: CT: Bathurst (1823).

Habitat

Habitat: Dry open-forest.
Altitude: 700 m **Annual rainfall:** 600 mm
Typical local abundance: Frequent.
Vegetation: Eucalypt open-forest
Substrate:
Exposure:

Conservation

Conservation: Possibly extinct north of Bathurst where the last collection was in 1823.

Grevillea evansiana (*G. diffusa* subsp. *evansiana*) PROTEACEAE

Life history

Growth form: Low dense spreading shrub rarely more than 0.5 m high.
Vegetative spread: No.
Longevity:
Primary juvenile period:
Flowers: Blackish red or rarely white, August–December, peak September. Pollinator unknown (Makinson 2000).
Fruit/seed: Capsule 12 mm long, with 1–2 winged seed (Makinson 2000) released at maturity, January.
Dispersal, establishment & growth: Diaspore: seed. Likely to have a food body for ant-dispersal (J. Howell pers. comm.).
Fire response: Probably killed, regenerates from soil-stored seed (Makinson 2000).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CT.
Distribution Sydney area: East of Rylstone.
Select locations: CT: Rylstone, Olinda, Currant Mountain Gap, Kandos.

Habitat

Habitat: Ridges, rocky areas.
Altitude: 600–800 m **Annual rainfall:** 700–800 mm
Typical local abundance: Frequent.
Vegetation: Eucalypt open-forest to woodland e.g. with *Eucalyptus sparsifolia, E. rossii*; heath e.g. with *Leptospermum parvifolium, L. sphaerocarpum, L. arachnoides, Calytrix tetragona, Leucopogon muticus.*

Substrate: Sandy soils over sandstone, low nutrients.
Exposure: Full sun to light shade.

Conservation

Conservation: Restricted local endemic, known only from an area east of Rylstone (Makinson 2000), listed as Vulnerable (Schedule 2) NSW *Threatened Species Conservation Act 1995*, and coded 2VC- on national rare species list (Briggs & Leigh 1996). Reported in Wollemi NP.

Grevillea floribunda subsp. ***floribunda*** **PROTEACEAE**

Seven Dwarfs Grevillea

Life history

Growth form: Erect shrub 0.4–2 m high, with simple leaves; with lignotuber or rhizome (Makinson 2000).
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Greenish yellow, with rusty brown hairs, May–November; primarily bird-pollinated (Makinson 2000).
Fruit/seed: Capsule, with 1–2 seed released at maturity.
Dispersal, establishment & growth: Diaspore: seed. Likely to have a food body for ant-dispersal (J. Howell pers. comm.).
Fire response: Variable, some populations resprout from rhizomes or lignotubers (Makinson 2000).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NT **CT** NWS CWS SWS NWP SWP; Qld, ?*Vic.
Distribution Sydney area: North from Bathurst.
Select locations: **CT**: Kelso.

Habitat

Habitat: Rocky situations.
Altitude: 750 m **Annual rainfall:** 600–650 mm
Typical local abundance: Rare.
Vegetation: Eucalypt open-forest, woodland or shrubland.
Substrate: Sandy or clay soils over granite or sandstone, low nutrients.
Exposure:

Conservation

Conservation: Conservation status unknown.

Grevillea humilis subsp. ***humilis*** (*G. linearifolia* 'Northern form') **PROTEACEAE**

Life history

Growth form: Low erect or rarely spreading shrub to 1 m high, with simple leaves.
Vegetative spread: Rhizomatous.
Longevity:
Primary juvenile period:
Flowers: Pink or white, August–November, insect-pollinated (Makinson 2000).
Fruit/seed: Capsule 8–11 mm long, with 1–2 seed released at maturity.
Dispersal, establishment & growth: Diaspore: seed. Likely to have a food body for ant-dispersal (J. Howell pers. comm.).
Fire response: Resprouts from rhizomes and regenerates from seed (Makinson 2000).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC CC.
Distribution Sydney area: Lower Hunter region.
Select locations: CC: Morisset, Cooranbong (locations from Makinson 2000).

Habitat

Habitat: Slopes, flats, seasonally waterlogged areas (Makinson 2000).
Altitude: 0–200 m **Annual rainfall:** 1000–1200 mm
Typical local abundance:
Vegetation: Eucalypt woodland.
Substrate: Heavy loam or clay loam soils (Makinson 2000).
Exposure:

Conservation

Conservation: Morisset–Cooranbong population is at southern geographical limit. Conservation status unknown.

Grevillea imberbis (*G. linearifolia* 'Kanangra/Braidwood form') **PROTEACEAE**

Life history

Growth form: Prostrate to low shrub 0.2–0.4 m high.
Vegetative spread: Rhizomatous.
Longevity:
Primary juvenile period:
Flowers: White to pale pink, August–February; presumed insect-pollinated (Makinson 2000).
Fruit/seed: Fruit not known.
Dispersal, establishment & growth: Diaspore: seed. Likely to have a food body for ant-dispersal (J. Howell pers. comm.).
Fire response: Regenerates from basal suckers and rhizomes, possibly also from seed (Makinson 2000).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CT ST.
Distribution Sydney area: Kanangra Walls.
Select locations: CT: Mt Seymour (Kanangra Tops).

Habitat

Habitat:
Altitude: 600–1000 m **Annual rainfall:** 900–1000 mm
Typical local abundance: Frequent.
Vegetation: Moist low heath or heathy woodland margins (Makinson 2000).
Substrate: Skeletal sandy soils over sandstone sheets (Makinson 2000), low nutrients.
Exposure:

Conservation

Conservation: Poorly known, conservation status unknown, Kanangra is northern geographical limit.

Grevillea johnsonii PROTEACEAE

Life history

Growth form: Single-stemmed shrub 2–4.5 m high, with simple leaves; Olde and Marriott report rhizomes (Makinson 2000).
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Red to orange, mainly spring.
Fruit/seed: Hairy capsule 12–16 mm long, bird-pollinated (Makinson 2000), with 1–2 seed released at maturity.
Dispersal, establishment & growth: Diaspore: seed. Likely to have a food body for ant-dispersal (J. Howell pers. comm.).
Fire response: Probably killed. Regenerates mainly from soil-stored seed (Makinson 2000).
Interaction with other organisms: Fungi *Placoasterella baileyi, Seimatosporium grevilleae* cause leaf spot diseases (B. Summerell pers. comm.).

Distribution

Status/origin: Native.
Botanical subregions: **CT** CWS.
Distribution Sydney area: Capertee Valley.
Select locations: **CT**: Mt Gundangaroo, Canobla Gap.

Habitat

Habitat: Rocky places.
Altitude: 400–700 m **Annual rainfall:** 600–700 mm
Typical local abundance: Frequent–occasional.
Vegetation: Scrub e.g. with *Beyeria viscosa, Muehlenbeckia rhyticarya.*
Substrate: Sandy soil on sandstone, low nutrients.
Exposure:

Conservation

Conservation: Coded 2RCi on national rare species list (Briggs & Leigh 1996).

Grevillea juniperina subsp. *juniperina* (includes *G. trinervis*) PROTEACEAE

Life history

Growth form: Prickly shrub 0.5–1.5 m high, with needle-like leaves; hybridises with *G. mucronulata* in Pitt Town area (Makinson 2000).
Vegetative spread: No.
Longevity:
Primary juvenile period:
Flowers: Red, yellow, pale orange or greenish, sporadic flowering, July–October; bird-pollinated (Makinson 2000).
Fruit/seed: Capsule 10–18 mm long, with 1–2 seed released at maturity, October–November; seed weight 20.8 mg ± 1.4 (Morris 2000).

Dispersal, establishment & growth: Diaspore: seed, soil-stored seedbank. Likely to have a food body for ant-dispersal (J. Howell pers. comm.). Germination experiment showed that: germination in untreated seeds 5–13%; germination mostly 30–40 days after treatment; smoke treatment increased amount of germination (x 6 with smoke alone); smoke treatment plus heat treatment resulted in at least 60% germination; heat treatment alone increased germination x 4; scarification significantly increased germination in unsmoked and unheated seeds; water uptake occurred rapidly in both scarified and unscarified seeds, mostly within 24 hrs and water loss was equally rapid on drying (Morris 2000). Tendency to colonise mechanically disturbed areas (Makinson 2000).
Fire response: Killed, regenerates from soil-stored seed only (Makinson 2000).
Interaction with other organisms: Important in ornamental horticulture, parent of many ornamental hybrids (Makinson 2000).

Distribution

Status/origin: Native.
Botanical subregions: CC.
Distribution Sydney area: Western Sydney.
Select locations: CC: Pitt Town, Windsor, Castlereagh NR, St Marys, Mt Druitt, Doonside.

Habitat

Habitat: Roadsides, ungrazed semi-cleared land.
Altitude: 0–50 m **Annual rainfall:** 700–800 mm
Typical local abundance: Occasional–frequent.
Vegetation: Cumberland Plain Woodland, Castlereagh Woodland e.g. with *Eucalyptus tereticornis, E. sideroxylon, E. eugenioides, E. fibrosa, E. moluccana, Melaleuca decora, Bursaria spinosa, Acacia falcata, Dillwynia tenuifolia.*
Substrate: Clay-loam soils on Wianamatta shale to Tertiary alluvium transition areas, medium–low nutrients.
Exposure: Full sun.

Conservation

Conservation: Local endemic, restricted to the western part of the Cumberland Plain. Listed as Vulnerable (Schedule 2) NSW *Threatened Species Conservation Act 1995*. Vulnerable in Western Sydney (James et al. 1999).

Grevillea juniperina subsp. *sulphurea* PROTEACEAE

Life history

Growth form: Dense, prickly, weakly erect shrub to 2 m high, very variable; may intergrade with *G. juniperina* subsp. *trinervis* in southern and western Blue Mountains (Makinson 2000).
Vegetative spread: No.
Longevity:
Primary juvenile period:
Flowers: Dull yellow to apricot-orange, mostly August–September; bird-pollinated (Makinson 2000).
Fruit/seed: Capsule 10–18 mm long, with 1–2 seed released at maturity.
Dispersal, establishment & growth: Diaspore: seed, soil-stored seedbank. Likely to have a food body for ant-dispersal (J. Howell pers. comm.).
Fire response: Killed, regenerates from soil-stored seed (Makinson 2000).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CT ST.
Distribution Sydney area: Coxs River, Berrima–Tallong.
Select locations: CT: Coxs River, Berrima, Paddys River, Barbers Creek.

Habitat

Habitat: Creekbanks.
Altitude: 600–900 m **Annual rainfall:** 800–900 mm
Typical local abundance: Occasional.
Vegetation: Riparian scrub e.g. with *Leptospermum* sp.
Substrate: Gravelly alluvium.
Exposure:

Conservation

Conservation: Several populations e.g. at Towrang, Canyonleigh and Tallong are in marginal and remnant bushland and under considerable threat; possibly extinct at Coxs River (Makinson 2000).

Grevillea juniperina subsp. *trinervis* PROTEACEAE

Life history

Growth form: Spreading low prickly shrub 0.5–1.2 (–2) m high; intergrades with subsp. *sulphurea*, with identification sometimes difficult (Makinson 2000).
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Dull orange to yellow, or red, mostly August–December; bird-pollinated (Makinson 2000).
Fruit/seed: Capsule 10–18 mm long, with 1–2 seed released at maturity.
Dispersal, establishment & growth: Diaspore: seed. Likely to have a food body for ant-dispersal (J. Howell pers. comm.).
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CT.
Distribution Sydney area: Sporadic, Western Blue Mountains.
Select locations: CT: Cullen Bullen, Hampton, Jenolan Caves, Kowmung.

Habitat

Habitat: Near creeks and swamps.
Altitude: 700–1000 m **Annual rainfall:** 600–1000 mm
Typical local abundance: Occasional–frequent.
Vegetation: Woodland e.g. with *Eucalyptus pauciflora, E. dalrympleana, Dillwynia retorta;* riverbank e.g. with *Lomatia myricoides.*
Substrate: Soils from granite, sandstone, alluvium, low to medium nutrients, poorly-drained.
Exposure:

Conservation

Conservation: Local endemic, restricted to NSW Central Tablelands, with rare, sporadic populations (Makinson 2000). Conservation status unknown.

Grevillea kedumbensis (*G. obtusifolia* subsp. *kedumbensis*) PROTEACEAE

Life history

Growth form: Multi-stemmed shrub 0.2–1 m high, with lignotuber; leaves simple.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Green to cream, most months, peak June–October; primarily bird-pollinated (Makinson 2000).
Fruit/seed: Hairy, faintly ridged capsule 13–15 mm long (Makinson 2000), with 1–2 seed released at maturity.
Dispersal, establishment & growth: Diaspore: seed. Likely to have a food body for ant-dispersal (J. Howell pers. comm.).
Fire response: Regenerates from seed, lignotuber and ?rhizomes (Makinson 2000).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CT.
Distribution Sydney area: Kedumba Valley to Yerranderie.
Select locations: CT: Kedumba Valley, Mt Solitary, Mt Cookem.

Habitat

Habitat:
Altitude: 500–800 m **Annual rainfall:** 800–900 mm
Typical local abundance: Frequent.
Vegetation: Eucalypt open-forest e.g. with *Eucalyptus eugenoides, E. crebra, E. punctata, E. tereticornis, E. siderophloia.*
Substrate: Sandy soils over quartzite or sandstone (Makinson 2000) and gravelly loam, low nutrients.
Exposure:

Conservation

Conservation: Local endemic restricted to an area between Kedumba Valley and Scotts Main Range (near Yerranderie). Listed as Endangered (Schedule 1) NSW *Threatened Species Conservation Act 1995*. Coded 2KCa on national rare species list (Briggs & Leigh 1996).

Grevillea lanigera PROTEACEAE

Life history

Growth form: Prostrate to mounded shrub or dense erect shrub 0.2–2 m high, with simple leaves, very variable in foliage and habit; rhizome present; sometimes intergrades with *G. rosmarinifolia* (Makinson 2000).
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Red to cream, or greenish. Flowers mainly July–December, sporadic in other months; primarily bird-pollinated (Makinson 2000).
Fruit/seed: Hairy capsule 10–15 mm long, with 1–2 seed released at maturity.
Dispersal, establishment & growth: Diaspore: seed. Likely to have a food body for ant-dispersal (J. Howell pers. comm.).
Fire response: Some populations regenerate from rhizomes (Makinson 2000).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: SC CT ST CWS SWS; Vic.
Distribution Sydney area: Abercrombie.
Select locations: CT: Abercrombie Caves, Wiarborough Creek, Wingello.

Habitat

Habitat: Rocky slopes or moist sites near water.
Altitude: 700–900 m **Annual rainfall:** 900–1100 mm
Typical local abundance:
Vegetation: Woodland e.g. with *Eucalyptus pauciflora, E. rubida, Bursaria spinosa, Melichrus urceolata, Poa sieberiana*; riparian scrub.
Substrate: Sandy, gravelly or light clayey soils over granite, sandstone, serpentine or limestone (Makinson 2000).
Exposure:

Conservation

Conservation: Conservation status unknown.

Grevillea laurifolia PROTEACEAE

Life history

Growth form: Prostrate trailing shrub, with divided leaves, often forming large mats to 4.5 m diameter, but shows no rooting at nodes or vegetative spread. Natural hybrids occur with *G. acanthifolia* (Makinson 2000).
Vegetative spread: No.
Longevity:
Primary juvenile period:
Flowers: Grey-red to red or deep maroon, mainly September–January, peak November. Smaller-flowered form of *G. laurifolia* occurs in Wentworth Falls to Valley Heights area (Makinson 2000).
Fruit/seed: Hairy capsule 9 mm long with reddish brown stripes or blotches, with 1–2 seed released at maturity.
Dispersal, establishment & growth: Diaspore: unwinged seed, gravity-dispersed. Seed probably with an elaiosome and probably ant-dispersed (Makinson 2000). May be light-requiring coloniser species. Establishes on disturbed land e.g. pine plantations, Newnes State Forest (R. Lembit pers comm.).
Fire response: Killed and regenerates from soil-stored seed (Makinson 2000), resprouting recorded at Leura (DHB).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CC CT.
Distribution Sydney area: Blue Mountains to Richlands.
Select locations: CC: Valley Heights, Springwood. CT: Newnes SF, Clarence, Bell, Mt Wilson, Mt Victoria, Megalong Valley, Katoomba, Wentworth Falls, Lawson, Loombah Plateau, Richlands.

Habitat

Habitat: Near swamps or on slopes or ridges.
Altitude: 500–700 m **Annual rainfall:** 1100–1400 mm
Typical local abundance: Frequent.
Vegetation: Open-forest e.g. with *Eucalyptus sieberi, E. piperita, E. dives, E. mannifera, E. macrorhyncha, E. fastigata, Mirbelia platyloboides, Phyllota squarrosa, Persoonia chamaepitys, P. myrtilloides, Acacia obtusifolia*; open-woodland to heath e.g. with *Eucalyptus burgessiana, E. sclerophylla, E. stricta, Banksia marginata.*
Substrate: Sandy to clayey soils on sandstone–shale or loam from fine quartzite, low nutrients, well-drained.
Exposure: Full sun–light shade.

Conservation

Conservation: Probably adequately conserved.

Grevillea linearifolia (*G. linearifolia* 'Hawkesbury Sandstone form') PROTEACEAE

Life history

Growth form: Open erect shrub usually 1–2 m high, not rhizomatous.
Vegetative spread: No.
Longevity:
Primary juvenile period: Peak flowering about 5 years after high intensity fire (at Lane Cove, P. Kubiak pers. comm.).
Flowers: White or rarely tinged pink, mainly August–December, sporadic January–May; insect-pollinated (Makinson 2000). Probably pollinated by Honeybees and native bees (P. Kubiak pers. comm.).
Fruit/seed: Capsule 13–15 mm long, with 1-2 seeds released at maturity, January–March; seed weight 24.1 mg ± 1.3 (Morris 2000), seeds with an elaiosome (lipid body) (Auld 1995).

Dispersal, establishment & growth: Diaspore: seed. Small ants *Iridomyrmex, Pheidole* sp. individuals working together move seed up to 20 cm and remove the elaiosome in pieces, or large solitary ants *Aphaenogaster, Thytidophonera* may drag the seeds to their nests; thus, up to 20% of seed may escape predation by native mammals e.g. Bush Rat *Rattus fuscipes*, Swamp wallaby *Wallabia bicolor* (Auld 1995).

Germination experiment showed that: germination in untreated seeds 5–13%; germination mostly 30–40 days after treatment; germination commenced earlier in smoked seeds; smoke treatment increased amount of germination; heat treatment alone increased germination x 2; smoke treatment plus heat treatment resulted in at least 60% germination; water uptake occurred rapidly in both scarified and unscarified seeds, mostly within 24 hrs and water loss was equally rapid on drying (Morris 2000), removal of seed coat results in 100% germination of dissected seeds (Morris et al. 2000). Persistent soil-stored seedbank, with high dormancy initially, estimated half-life 9–10 years (Auld et al. 2000).
Fire response: Killed after high intensity fire 1/94 (at Lane Cove & Narrabeen Lake, P. Kubiak pers. comm.). Regenerates from soil-stored seed (Makinson 2000).
Interaction with other organisms: Pre-dispersal seed predation 1–2% by weevils *Cydmaea dorsalis* and 5–22% by wasps *Eurytoma* sp. (Auld & Denham 2001b).

Distribution

Status/origin: Native.
Botanical subregions: CC SC CT.
Distribution Sydney area: Widespread, mainly on coast.
Select locations: CC: Putty, Gosford, St Ives, Cheltenham, Lane Cove River, Cambewarra. CT: Lawson (Makinson 2000).

Habitat

Habitat:
Altitude: 0–800 m **Annual rainfall:** 1100–1400 mm
Typical local abundance: Frequent.
Vegetation: Shrubby eucalypt woodland.
Substrate: Sandy, skeletal soils over sandstone, low nutrients, well-drained sites. Occasionally in light sandy clayey or pebbly pseudolateritic soils (Makinson 2000).
Exposure: Medium shade to full sun.

Conservation

Conservation: Probably adequately conserved. Mainly coastal with a disjunct population at Lawson in Lower Blue Mountains. Reported in Bouddi NP, Brisbane Water NP, Ku-ring-gai Chase NP, Garigal NP, Lane Cove NP, Sydney Harbour NP.

Grevillea longifolia PROTEACEAE

Life history

Growth form: Erect to spreading shrub 1.5–6 m high, with divided leaves, sometimes confused with *G. aspleniifolia* (Makinson 2000).
Vegetative spread: No.
Longevity:
Primary juvenile period: Probably 10–30 years (A. Auld pers. comm.).
Flowers: Pink to red or rarely pale orange, July–January, peak September.
Fruit/seed: Hairy capsule 13–16 mm long, with reddish brown stripes or blotches, 1–2 seed, released at maturity. Seed weight 112–143 mg (Auld & Denham 1999), seeds without an elaiosome (Auld 1995).
Dispersal, establishment & growth: Diaspore: seed, with no obvious dispersal mechanism (Auld 1995) but can be moved by water in floods (A. Auld pers. comm.), unwinged (Makinson 2000), probably gravity-dispresed locally.
Fire response: Killed, regenerates from soil-stored seed (Makinson 2000).
Interaction with other organisms: Seed predation by insects, and on the soil surface by native mammals e.g. Bush Rat *Rattus fuscipes*, Swamp Wallaby *Wallabia bicolor* (Auld 1995, Auld & Denham 1999).

Distribution

Status/origin: Native.
Botanical subregions: CC ?CT.
Distribution Sydney area: Mainly Woronora Plateau.
Select locations: CC: Burwood (1898), Carlton (1892), Woronora River, Waterfall, Lucas Hts, Kentlyn, Woolwash, Wedderburn, Appin, Helensburgh, O'Hares Creek, Bulli, Springwood (1903). CT: Lawson (1898).

Habitat

Habitat: Beside creeks, seepage zones, also on plateaus.
Altitude: 0–800 m **Annual rainfall:** 900–1400 mm
Typical local abundance: Rare–frequent.
Vegetation: Along creeks e.g. with *Lomatia myricoides, Tristania neriifolia, Tristaniopsis laurina, Eucalyptus pilularis, Ceratopetalum apetalum*; moist open-forest e.g. with *Angophora costata, Eucalyptus agglomerata, E. piperita, Doryanthes excelsa*; woodland e.g. with *Angophora costata, Eucalyptus piperita, E. oblonga, Corymbia gummifera.*
Substrate: Sandy to yellow clay soils on Hawkesbury Sandstone or sandstone/shale transition, low nutrients.
Exposure: Light shade to mid-shade.

Conservation

Conservation: Local endemic coded 2RC- on national rare species list (Briggs & Leigh 1996). Extinct in Burwood–Carlton area, and probably also in Blue Mountains. Reported in Heathcote NP, Royal NP. Not adequately conserved (A. Auld pers. comm.).

Grevillea molyneuxii (*G. sericea* misapplied) PROTEACEAE

Life history

Growth form: Spreading shrub 0.2–1 m high, with narrow leaves.
Vegetative spread: No.
Longevity:
Primary juvenile period:
Flowers: Red, mainly August–November, bird-pollinated (Makinson 2000).
Fruit/seed: Capsule 12–14 mm long, with 1–2 seed released at maturity.
Dispersal, establishment & growth: Diaspore: seed. Likely to have a food body for ant-dispersal (J. Howell pers. comm.).
Fire response: Killed, regenerates from soil-stored seed (Makinson 2000).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CT.
Distribution Sydney area: Southern Highlands.
Select locations: CT: Wingello SF, Tallong.

Habitat

Habitat: Seepage sites.
Altitude: 500–600 m **Annual rainfall:** 1000 mm
Typical local abundance: Frequent.
Vegetation: Heath e.g. with *Calytrix tetragona, Allocasuarina distyla, Isopogon anethifolius, Acacia elongata, A. suaveolens, A. ulicifolia, Banksia spinulosa, Epacris microphylla.*
Substrate: Shallow sandy soils over sandstone, seasonally wet sites, low nutrients.
Exposure: Full sun.

Conservation

Conservation: Restricted local endemic, listed as Vulnerable (Schedule 2) NSW *Threatened Species Conservation Act 1995*, coded 2K on national rare species list (Briggs & Leigh 1996). Confined to Tallong–Wingello area. Reported in Morton NP (A. Auld pers. comm.). Conservation adequacy unknown.

Grevillea mucronulata PROTEACEAE

Life history

Growth form: Spreading or erect shrub, 0.3–3.5 m high, with considerable variation in leaf form, habit, regeneration mode and flower colour, with populations consistent on a geographic basis; Cumberland Plain form is lignotuberous, Lower Blue Mountains form without lignotuber (Makinson 2000).
Vegetative spread: No.
Longevity: ? short-medium.
Primary juvenile period:
Flowers: Green to reddish brown, April–September; primarily bird-pollinated (Makinson 2000).
Fruit/seed: Hairy capsule 13–20 mm long, with 1–2 seed released at maturity, October–December; seed weight 30.6 mg ± 1.4 (Morris 2000).
Dispersal, establishment & growth: Diaspore: seed. Appears to colonise disturbed sites. Likely to have a food body for ant-dispersal (J. Howell pers. comm.). Germination experiment showed that: germination in untreated seeds c. 20%; germination mostly 30–40 days after treatment; germination commenced earlier in smoked seeds; smoke treatment increased amount of germination; no response to heat treatment and smoking did not change this; scarification significantly increased germination in unsmoked and unheated seeds; water uptake occurred rapidly in both scarified and unscarified seeds, mostly within 24 hrs and water loss was equally rapid on drying (Morris 2000).
Fire response: Variable, populations in the Richmond to Blacktown area probably resprout from lignotubers. Populations from Singleton to Warragamba probably killed.
Interaction with other organisms: Fungus *Placoasterella baileyi* causes leaf spot disease (B. Summerell pers. comm.).

Distribution

Status/origin: Native.
Botanical subregions: CC SC CT CWS.
Distribution Sydney area: Widespread.
Select locations: CC: Howes Mountain, Maroota, Londonderry, Kenthurst, Galston, Kurnell, Oatley, Heathcote, Yarramundi, Wallacia, Springwood, Megalong Valley, Avon Dam, Thirlmere.
CT: Nullo Mountain, Gospers Mountain, Glen Davis, Newnes Junction, Kings Tableland.

Habitat

Habitat: Plateaus, ridges, steep slopes.
Altitude: 0–1000 m **Annual rainfall:** 800–1400 mm
Typical local abundance: Frequent.
Vegetation: Open-forest e.g. with *Angophora costata, Eucalyptus agglomerata, E. piperita, Corymbia gummifera, Ceratopetalum gummiferum*; woodland e.g. with *Angophora costata, Eucalyptus sclerophylla, E. parramattensis, Angophora bakeri.*
Substrate: Sandy to clayey soils, on sandstones and shales or rarely granite, low nutrients.
Exposure:

Conservation

Conservation: Widespread and probably adequately conserved. Reported in Wollemi NP, Marramarra NP, Ku-ring-gai Chase NP, Sydney Harbour NP, Royal NP.

Grevillea obtusiflora subsp. ***fecunda*** **PROTEACEAE**

Life history

Growth form: Low spreading to erect shrub 0.5–1 m high, with rhizome (Makinson 2000).
Vegetative spread: Rhizomatous (Makinson 1997).
Longevity:
Primary juvenile period:
Flowers: Pale pink to crimson, August–December, primarily bird-pollinated (Makinson 2000).
Fruit/seed: Capsule 11–13 mm long, with 1–2 seed 9 mm long, released at maturity; copious numbers of fruit set (Makinson 1997),
Dispersal, establishment & growth: Diaspore: seed, probably ant-dispersed (Makinson 1997), establishes on disturbed ground, associated with mechanical disturbance of soil along the road (Makinson 1997, 2000).
Fire response: Resprouts from rhizomes and regenerates from seed (Makinson 2000).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CT.
Distribution Sydney area: Capertee Valley.
Select locations: CT: Clandulla SF, Pantoneys Crown.

Habitat

Habitat: Rocky ridges, talus slopes.
Altitude: 500–600 m **Annual rainfall:** 600 mm
Typical local abundance: Frequent to occasional.
Vegetation: Eucalypt open-forest e.g. with *Eucalyptus tenella, E. fibrosa, E. nubila, E. macrorrhyncha, E. punctata, Callitris endlicheri, Monotoca elliptica, Acacia buxifolia, Persoonia linearis.*
Substrate: Distinctive orange loamy soil with sandstone boulders, the soil type and *Eucalyptus tenella* may be good indicators for the occurrence of this *Grevillea* (Makinson 1997).
Exposure:

Conservation

Conservation: Local endemic, restricted to the Capertee Valley, SSE of Kandos and probably substrate-specific (Makinson 1997). Listed as Endangered (Schedule 1) NSW *Threatened Species Conservation Act 1995*, coded 2E on national rare species list (Briggs & Leigh 1995). Reported in Gardens of Stone NP (A. Auld pers. comm.). Inadequately conserved.

Grevillea obtusiflora subsp. *obtusiflora* PROTEACEAE

Life history

Growth form: Shrub to 0.7 m high.
Vegetative spread: Wholly dependent on rhizomatous spread, up to 1.3 m from parent (Makinson 1997).
Longevity: Indefinite.
Primary juvenile period:
Flowers: Pink to pinkish red with cream, September–December. July–October. Closely related *Grevillea* species are primarily bird-pollinated (Makinson 2000).
Fruit/seed: Fruits, seed and seedlings have never been recorded (Makinson 2000).
Dispersal, establishment & growth:
Fire response: Regenerates from rhizomes only (Makinson 2000).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CT.
Distribution Sydney area: Clandulla SF.
Select locations: CT: Clandulla SF.

Habitat

Habitat: Open-forest.
Altitude: 700 m **Annual rainfall:** 600 mm
Typical local abundance: Frequent.
Vegetation: Open-forest e.g. with *Eucalyptus rossii, E. punctata,* grassy understorey with scattered shrubs e.g. *Exocarpus* sp., *Persoonia linearis, Hakea decurrens, Acacia dawsonii, Acacia buxifolia.*
Substrate: Gravelly loam derived from sandstone. Loamy soil over granite.
Exposure:

Conservation

Conservation: Local endemic, restricted to Clandulla area north of Capertee (R. Makinson pers. comm.). Listed as Endangered (Schedule 1) NSW *Threatened Species Conservation Act 1995. Grevillea obtusiflora* coded 2E on national rare species list (Briggs & Leigh 1995). Populations may be largely clonal (R. Makinson pers. comm.).

Grevillea oldei (*G. trinervis,* misapplied *G. capitellata)* PROTEACEAE

Life history

Growth form: Diffuse shrub to 1.2 m high, with conspicuously 3-nerved leaves; apparently hybridizes with *G. speciosa* in Kulnura area (Makinson 2000).
Vegetative spread: No.
Longevity:
Primary juvenile period:
Flowers: Red, June–February, pollinator not known (Makinson 2000).
Fruit/seed: Capsule 14–15 mm long, with 1–2 seed released at maturity.
Dispersal, establishment & growth: Diaspore: seed. Likely to have a food body for ant-dispersal (J. Howell pers. comm.).
Fire response: Killed, regenerates from soil-stored seed (Makinson 2000).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CC.
Distribution Sydney area: Mangrove Mountain to Woy Woy.
Select locations: CC: Mangrove Mountain, Ourimbah, Narara, Gosford, Woy Woy.

Habitat

Habitat: Heath or woodland.
Altitude: 0–300 m **Annual rainfall:** 1400–1600 mm
Typical local abundance:

Vegetation: Woodland e.g. with *Angophora costata, E. piperita, E. umbra, E. haemastoma, Corymbia gummifera.*
Substrate: Shallow, sandy soils on sandstone, low nutrients, well-drained.
Exposure:

Conservation

Conservation: Very localised endemic, coded 2RC- on national rare species list (Briggs & Leigh 1996). Restricted to a small area from Mangrove area to Woy Woy and Gosford (Makinson 2000). Conservation status unknown.

Grevillea oleoides PROTEACEAE

Life history

Growth form: Erect shrub 0.5–3 m high, with great variation in leaf form and size; the riparian form has narrower leaves (Makinson 2000).
Vegetative spread: Sometimes rhizomatous.
Longevity: Indefinite (D. Keith pers. comm.).
Primary juvenile period:
Flowers: Red, deep reddish pink or pale pink, peak July–November, sporadically at other times. Bird-pollinated (Makinson 2000).
Fruit/seed: Capsule 10–15 mm long, with 1–2 seed, weight 26–30 mg, released at maturity. Seed with food body (J. Howell pers. comm.).
Dispersal, establishment & growth: Diaspore: seed, food body ant-adapted for dispersal (Westoby et al. 1990), local seed dispersal (Keith 1991). Soil-stored seedbank, recruitment mainly after fire (D. Keith pers. comm.).
Fire response: Regenerates from soil-stored seed and sometimes rhizomes (Makinson 2000). Resprouts, secondary juvenile period 4 years (D. Keith pers. comm.).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CC CT.
Distribution Sydney area: Mainly coast and Woronora Plateau.
Select locations: CC: Heathcote, Helensburgh, Campbelltown, Bargo, Bulli. CT: Wentworth Falls, Hill Top, Mittagong, Robertson, Kangaloon.

Habitat

Habitat: Ridgetops or flood-zone of river banks.
Altitude: 0–1000 m **Annual rainfall:** 1200–1600 mm
Typical local abundance: Occasional–frequent.
Vegetation: Open-forest and shrubby woodland e.g. with *Angophora costata, Corymbia gummifera, E. punctata, Syncarpia glomulifera, Banksia spinulosa, Gompholobium latifolium;* creekside vegetation e.g. with *Tristaniopsis laurina, Tristania neriifolia, Allocasuarina littoralis, Grevillea longifolia, Hakea salicifolia, Bossiaea rhombifolia, Pseudanthus pimelioides.*
Substrate: Skeletal sandy soils on sandstones, low-nutrients.
Exposure:

Conservation

Conservation: Local endemic, widespread but not common. Conservation status unknown. Reported in Royal NP.

Grevillea parviflora subsp. *parviflora* PROTEACEAE

(*G. linearifolia 'Narrower-leaved Sydney form'*)

Life history

Growth form: Low open to erect shrub usually 0.3–1 m high, with rhizomes (Makinson 2000).
Vegetative spread:
Longevity: 25–60 years (D. Keith pers. comm.).
Primary juvenile period:
Flowers: White with rusty brown hairs, July–December; insect-pollinated (Makinson 2000).
Fruit/seed: Capsule 8–10 mm long, with 1–2 seed released at maturity.
Dispersal, establishment & growth: Diaspore: seed, gravity-dispersed. Recruitment mainly after fire from soil-stored seedbank (Keith 1991). Likely to have a food body for ant-dispersal (J. Howell pers. comm.).
Fire response: Killed by fire (D. Keith pers. comm.). Sometimes regenerates from rhizomes (Makinson 2000).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CC.
Distribution Sydney area: Mainly Woronora Plateau.
Select locations: CC: Cooranbong, Georges River, Kemps Creek, Wedderburn, Tahmoor.

Habitat

Habitat: Ridges, steep rocky slopes.
Altitude: 0–300 m **Annual rainfall:** 800–1000 mm
Typical local abundance: Rare to frequent.
Vegetation: Shrubby woodland e.g. with *Eucalyptus fibrosa, E. sclerophylla, Corymbia gummifera, Angophora bakeri, Allocasuarina littoralis, Melaleuca nodosa, Grevillea mucronulata, Banksia spinulosa.*
Substrate: Sandy to gravelly clay over shale, low nutrients.
Exposure:

Conservation

Conservation: Local endemic. Listed as Vulnerable (Schedule 2) NSW *Threatened Species Conservation Act 1995.* Mainly Woronora Plateau to Prospect (historically), with isolated northern occurrences on western shore of Lake Macquarie and a possible southern occurrence near Moss Vale (R. Makinson pers. comm.).

Grevillea parviflora subsp. *supplicans* PROTEACEAE

Life history

Growth form: Low shrub 0.3–0.6 m high, major branches spreading with leaves held skyward; sometimes grows sympatrically with *G. linearifolia* with no interbreeding (Makinson 2000).
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: White with rusty brown hairs, August–November; insect-pollinated (Makinson 2000).
Fruit/seed: Capsule 8–10 mm long, with 1–2 seed, released at maturity. Seed with food body (J. Howell pers. comm.).
Dispersal, establishment & growth: Diaspore: seed, ant-dispersed locally (J. Howell pers. comm.).
Fire response: Probably killed, regenerates from soil-stored seed and possibly rhizomes (Makinson 2000).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CC.
Distribution Sydney area: Arcadia–Maroota area.
Select locations: CC: Maroota, Glenorie, Berrilee, Arcadia.

Habitat

Habitat: Ridges.
Altitude: 0–200 m **Annual rainfall:** 800–1000 mm
Typical local abundance: Frequent.
Vegetation: Heathy woodland e.g. with *Corymbia eximia, Eucalyptus oblonga, E. squamosa, Angophora bakeri, Kunzea ambigua, K. rupestris, Calytrix tetragona, Leptospermum parvifolium, L. trinervium, Zieria laevigata, Petrophile pulchella* .
Substrate: Skeletal sandy soils over massive sandstones, low nutrients.
Exposure: Full sun.

Conservation

Conservation: Local endemic taxon, listed as Endangered (Schedule 1) NSW *Threatened Species Conservation Act 1995*. Reported in Marramarra NP.

Grevillea patulifolia *(G. linearifolia 'Southern Sandstone form')* **PROTEACEAE**

Life history

Growth form: Erect or low spreading shrub 0.8–2 m high.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Pale pink to dark mauve pink, or rarely white, July–February, peak October; probably insect-pollinated (Makinson 2000).
Fruit/seed: Capsule 11 mm long, with 1–2 seed released at maturity.
Dispersal, establishment & growth: Diaspore: seed. Likely to have a food body for ant-dispersal (J. Howell pers. comm.).
Fire response: Regenerates from soil-stored seed and (most populations?) basal suckers and/or rhizomes (Makinson 2000).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CC SC CT SC; Vic.
Distribution Sydney area: South from Heathcote.
Select locations: CC: Heathcote, Picton, Yerrinbool, Jamberoo. CT: Mittagong, Fitzroy Falls, Bundanoon, Barbers Creek.

Habitat

Habitat:
Altitude: 0–700 m **Annual rainfall:** 900–1200 mm
Typical local abundance: Occasional–frequent.
Vegetation: Heath and woodland e.g. with *Eucalyptus sclerophylla.*
Substrate: Sandy soils on sandstone, low nutrients, possibly poorly-drained.
Exposure:

Conservation

Conservation: Heathcote is the northern geographical limit. Conservation status unknown.

Grevillea phylicoides (*G.buxifolia* subsp. *phylicoides*) PROTEACEAE

Grey Spider Flower

Life history

Growth form: Shrub 1-2 m high.
Vegetative spread: No.
Longevity:
Primary juvenile period:
Flowers: Hairy, grey with brown markings, sporadic flowering, mainly June–February; insect-pollinated (Makinson 2000).
Fruit/seed: Hairy capsule 15 mm long, with 1–2 seed released at maturity.
Dispersal, establishment & growth: Diaspore: seed. Likely to have a food body for ant-dispersal (J. Howell pers. comm.).
Fire response: Killed, regenerates from soil-stored seed (Makinson 2000).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CC CT.
Distribution Sydney area: Mainly Blue Mountains.
Select locations: CC: Hawkesbury Lookout, Glenbrook, Linden, Springwood, Oakdale, Warragamba. CT: Kings Tableland, Lawson.

Habitat

Habitat: Ridgetops, hillsides.
Altitude: 0–1000 m **Annual rainfall:** 900–1400 mm
Typical local abundance: Occasional–frequent.
Vegetation: Open-forest and woodland e.g. with *Corymbia gummifera, C. eximia, Eucalyptus punctata, E. piperita, E. sclerophylla, Syncarpia glomulifera, Angophora costata, A. bakeri, Grevillea mucronulata, Acacia longifolia, Persoonia levis, P. linearis.*
Substrate: Skeletal sandy soils over sandstone, low nutrients.
Exposure: Full sun to light shade.

Conservation

Conservation: Local endemic species, reported in Wollemi NP, Blue Mountains NP. Conservation adequacy unknown.

Grevillea ramosissima subsp. *ramosissima* PROTEACEAE

Life history

Growth form: Prickly shrub to 1.5 m high, with stiff and leathery divided leaves; rare intergrades with G. triternata occur (Makinson 2000).
Vegetative spread: Rhizomatous spread confirmed for southern part of the range (ST, SWS) may also occur elsewhere (R. Makinson pers. comm.).
Longevity:
Primary juvenile period:
Flowers: Cream to pale yellow, August–November; adapted for insect-pollination (Makinson 2000).
Fruit/seed: Hairy capsule 7–10 mm long, with reddish brown stripes or blotches and 1–2 winged seed, released at maturity.
Dispersal, establishment & growth: Diaspore: seed, soil-stored seedbank. Likely to have a food body for ant-dispersal (J. Howell pers. comm.).
Fire response: Generally killed, regenerates from soil-stored seed; some populations regenerate from rhizomes (Makinson 2000).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CC NT CT ST NWS CWS SWS.
Distribution Sydney area:
Select locations: CC: Yerranderie. CT: Rylstone, Capertee Valley, Mullions Range, Cargo, Orange, Hill End, Mt Solitary, Mittagong.

Habitat

Habitat: Rocky ridges.
Altitude: 160–1000 m **Annual rainfall:** 600–1000 mm
Typical local abundance: Rare–frequent.
Vegetation: Woodland with shrubby understorey e.g. with *Eucalyptus punctata, E. eugenioides, E. crebra, E. sideroxylon.*
Substrate: Sandy or loamy soils over sandstone, granite, metamorphics, low nutrients.
Exposure:

Conservation

Conservation: Conservation status unknown.

Grevillea raybrownii *(prev. included under G. triternata)* **PROTEACEAE**

Life history

Growth form: Bushy shrub to 1.5 m high, with divided leaves. Very closely related to *G. triternata,* from which it is barely distinct at species level (Makinson 2000).
Vegetative spread: No.
Longevity:
Primary juvenile period:
Flowers: White, August–November, probably insect-pollinated (Makinson 2000).
Fruit/seed: Hairy capsule 12 mm long, with reddish brown stripes or blotches and 1–2 winged seeds released at maturity.
Dispersal, establishment & growth: Diaspore: seed, gravity-dispersed. Likely to have a food body for ant-dispersal (J. Howell pers. comm.).
Fire response: Probably killed, regenerates from seed (?only) (Makinson 2000).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CC CT.
Distribution Sydney area: Illawarra–Southern Highlands.
Select locations: CC: ?Avon Dam, Dapto. CT: Mittagong, Berrima, ?Bungonia, Bullio.

Habitat

Habitat: Edges of cleared areas e.g. tracks, car park, ridgetop.
Altitude: 0–700 m **Annual rainfall:** 700–1200 mm
Typical local abundance: Frequent–occasional.
Vegetation: Eucalypt open-forest e.g. with *Eucalyptus sclerophylla, E. mannifera* subsp. *gulickii, E. globoidea;* shrubland e.g. with *Leptospermum scoparium, Eriostemon australasius, Bossiaea heterophylla, Banksia ericifolia;* moist heath.
Substrate: Sandy soil, gravelly loam from sandstone, low nutrients.
Exposure: Full sun to light shade.

Conservation

Conservation: Restricted to Dapto–Robertson–Berrima area. Possibly also at Bungonia (R. Makinson pers. comm.). Coded 2KC- on national rare species list (Briggs & Leigh 1996). Conservation adequacy unknown.

Grevillea rivularis PROTEACEAE

Carrington Falls Grevillea

Life history

Growth form: Dense spreading prickly shrub 2–2.5 m high, with divided leaves.
Vegetative spread: No.
Longevity:
Primary juvenile period:
Flowers: Cream becoming pearly pink or grey, September–April (Makinson 2000).
Fruit/seed: Hairy capsule 8–10 mm long, with reddish brown stripes or blotches and 1–2 winged seeds, released at maturity.
Dispersal, establishment & growth: Diaspore: unwinged seed, probably with an elaiosome (Makinson 2000), short-distance gravity-dispersed. Likely to have a food body for ant-dispersal (J. Howell pers. comm.).
Fire response: Probably killed and regenerates from seed only (Makinson 2000), obligate seeder (A. Auld pers. comm.).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CT.
Distribution Sydney area: Carrington Falls.
Select locations: CC: Carrington Falls.

Habitat

Habitat: Moist creekbanks, rock ledges.
Altitude: 400–600 m **Annual rainfall:** 1000–1600 mm
Typical local abundance: Occasional–frequent.
Vegetation: Riparian vegetation e.g. with *Leptospermum polygalifolium, Acacia binervata, A. longifolia, Hakea dactyloides, H. salicifolia, Callicoma serratifolia, Lomandra longifolia, Tristania.*
Substrate: Sandy alluvium from sandstone, low nutrients.
Exposure: Mid shade.

Conservation

Conservation: Local endemic restricted to the Carrington Falls area SE of Moss Vale (Makinson 2000), listed as Endangered (Schedule 1) NSW *Threatened Species Conservation Act 1995*. Coded 2VCi on national rare species list (Briggs & Leigh 1996). Conservation adequacy unknown.

Grevillea rosmarinifolia subsp. *rosmarinifolia* PROTEACEAE

Life history

Growth form: Compact to open shrub 0.2–2 m high; very variable foliage (Makinson 2000).
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Pink to red or rarely yellow, pale green, cream or orange, July-December, primarily bird-pollinated (Makinson 2000).
Fruit/seed: Hairy capsule 8–11 mm long, with 1–2 seed released at maturity.
Dispersal, establishment & growth: Diaspore: seed. Likely to have a food body for ant-dispersal (J. Howell pers. comm.).
Fire response: Regenerates usually from seed, but in some populations also from rhizomes (Makinson 2000).
Interaction with other organisms: Fungi *Seimatosporium grevilleae, S. kennedyae* causes leaf spot disease (B. Summerell pers. comm.).

Distribution

Status/origin: Native.
Botanical subregions: CT ST SWS; Vic, *S.A.
Distribution Sydney area: Kowmung–Jenolan area.
Select locations: CT: Kowmung, Hampton, Hartley.

Habitat

Habitat: Rocky slopes or on creekbanks subject to inundatation.
Altitude: 600–1200 m **Annual rainfall:** 800–1000 mm
Typical local abundance: Rare–occasional.
Vegetation: Eucalypt open-forest.
Substrate: Loamy sand, alluvium, medium nutrients.
Exposure:

Conservation

Conservation: Conservation status unknown.

Grevillea sericea subsp. ***riparia*** *(G. riparia)* **PROTEACEAE**

Life history

Growth form: Shrub 0.5–2 m high.
Vegetative spread: Possibly from basal suckers (Makinson 2000).
Longevity:
Primary juvenile period:
Flowers: Deep purplish pink, August–November; probably insect-pollinated (Makinson 2000).
Fruit/seed: Capsule , with 1–2 seed released at maturity. Seed with food body (J. Howell pers. comm.).
Dispersal, establishment & growth: Diaspore: seed, ant-dispersed locally (J. Howell pers. comm.). Likely to have a food body for ant-dispersal (J. Howell pers. comm.).
Fire response: Regeneration possibly from basal suckers (Makinson 2000).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CC.
Distribution Sydney area: Foot of Blue Mountains escarpment.
Select locations: CC: Lower Colo, lower Grose River, Glenbrook Creek.

Habitat

Habitat: Riverbanks, floodzones of permanent streams.
Altitude: 0–50 m **Annual rainfall:** 800–900 mm
Typical local abundance: Occasional–frequent.
Vegetation: Riparian floodzone e.g. with *Allocasuarina littoralis, Aacia longifolia, Acacia binervia, Lomandra fluviatilis, Epacris sparsa, Daviesia corymbosa, Goodenia ovata.*
Substrate: Silty sand, deep alluvial sandy loam soils, low nutients.
Exposure: Dense shade, subject to periodic flooding.

Conservation

Conservation: Local endemic restricted to the banks of the lower Grose and Colo Rivers and Glenbrook Creek and possibly Erskine Creek (Makinson 2000). Conservation status unknown.

Grevillea sericea subsp. ***sericea*** *(G. stricta)* **PROTEACEAE**

Life history

Growth form: Shrub 0.5–2 m high.
Vegetative spread: Generally no.
Longevity: Short–medium (to 20 years). Main growth period December–April.
Primary juvenile period: More than 2 years after high intensity fire 1/94 (at Lane Cove, P. Kubiak pers. comm.), 4–6 years (Benson 1985).
Flowers: Deep pink, pale pink or white, at any time of year but mostly July–January, peak September–October. Peak flowering 4–5 years after high intensity fire (1/94) at Lane Cove (P. Kubiak pers. comm.). Insect-pollinated (Makinson 2000). large native bees may assist pollination (P. Kubiak pers. comm.)
Fruit/seed: Capsule 9–16 mm long, with 1–2 seed released at maturity, January–March; seed weight 24.1 mg ± 1.3 (Morris 2000).

Dispersal, establishment & growth: Diaspore: seed, with food body ant-adapted for dispersal (Westoby et al. 1990, Rice & Westoby 1981). Soil-stored seedbank. Germination experiment showed that: germination in untreated seeds 5–13%; germination mostly 30–40 days after treatment; smoke treatment increased amount of germination; no response to heat treatment and smoking did not change this; water uptake occurred rapidly in both scarified and unscarified seeds, mostly within 24 hrs and water loss was equally rapid on drying (Morris 2000), additive relationship between smoke and heat, with smoke having the most influence (Kenny 2000).
Fire response: Populations on skeletal soils over massive sandstones (i.e. over most of its range on Gosford, Hornsby, Woronora Plateaus) are generally killed (Makinson 2000). Re-establishment from soil-stored seed is most common. Killed after high intensity fire 1/94 (at Lane Cove & Narrabeen Lake, P. Kubiak pers. comm.). Some root suckering (at Wallarah Creek and Leura) and basal resprouting (at Brisbane Water) has been observed. Resprouting from base and root suckers 6–12 months after fire (at Wyee 1980, Herb. notes).

Interaction with other organisms: Host of scale insect, possibly *Gascardia destructor.* Fungus *Placoasterella baileyi* causes a leaf spot disease (B. Summerell pers. comm.). Pre-dispersal seed predators include weevils *Cydmaea dorsalis* (Auld & Denham 2001b).

Distribution

Status/origin: Native.
Botanical subregions: CC CT CWS.
Distribution Sydney area: Widespread.
Select locations: CC: Wyong, Kariong, Berowra, Palm Beach, Terry Hills, Narrabeen, Cheltenham, Lane Cove, Pennant Hills, Bondi, Oatley, Engadine, Yarramundi, Springwood.
CT: Glen Davis, Newnes Plateau, Bilpin, Kings Tableland, Lawson, Linden.

Habitat

Habitat: Plateaus, ridges, slopes.
Altitude: 0–1000 m **Annual rainfall:** 700–1400 mm
Typical local abundance: Frequent–occasional.
Vegetation: Open-forest to woodland e.g. with *Corymbia gummifera, Eucalyptus capitellata, Angophora costata, Eucalyptus sieberi, E. haemastoma, Acacia linifolia*; shrubland/heath e.g. with *Grevillea buxifolia, Hakea sericea, H. laevipes, H. teretifolia, Banksia serrata, Leptospermum squarrosum.*
Substrate: Gravelly, loamy to sandy, skeletal soils over sandstone, low nutrients.
Exposure: Full sun to light shade.

Conservation

Conservation: Widespread and probably adequately conserved. Reported in Wollemi NP, Bouddi NP, Brisbane Water NP, Ku-ring-gai Chase NP, Garigal NP (east), Lane Cove NP, Sydney Harbour NP. Northern populations (Mudgee to Goulburn River) may be a distinct taxon (R. Makinson pers. comm.).

Grevillea shiressii PROTEACEAE

Life history

Growth form: Erect shrub 1.5–5 m high, with simple leaves 8–19 cm long.
Vegetative spread: No.
Longevity:
Primary juvenile period:
Flowers: Bluish to mauve and cream, mainly July-December, bird-pollinated (Makinson 2000).
Fruit/seed: Capsule 14–16 mm long, with 1–2 seeds, weight 25 mg, released at maturity, October.
Dispersal, establishment & growth: Diaspore: seed, with food body adapted for ant-dispersal (Auld & Denham 2001b, Auld et al. 1991), dispersed by ants (Auld & Denham 1999).
Fire response: Killed, regenerates from seed only (Makinson 2000).
Interaction with other organisms: Pre-dispersal seed predation 46% by wasps *Eurytoma* sp. (Auld & Denham 2001b).

Distribution

Status/origin: Native.
Botanical subregions: CC.
Distribution Sydney area: Brisbane Water.
Select locations: CC: Mooney Mooney Creek, Mullet Creek.

Habitat

Habitat: Creekbanks close to water.
Altitude: 0–30 m **Annual rainfall:** 1200 mm
Typical local abundance: Frequent.
Vegetation: Moist open-forest e.g. with *Eucalyptus deanei, Syncarpia glomulifera, Angophora floribunda;* riparian vegetation e.g. with *Tristaniopsis laurina, Lomatia myricoides* (R. Makinson pers. comm.).
Substrate: Sandy soil on alluvium, sandstone.
Exposure:

Conservation

Conservation: Very, restricted local endemic, listed as Vulnerable (Schedule 2) NSW *Threatened Species Conservation Act 1995*. Coded 2VCit on national rare species list (Briggs & Leigh 1996). Reported in Brisbane Water NP. Very localised, review of conservation status needed (A. Auld pers. comm.).

Grevillea speciosa PROTEACEAE

Red Spider Flower

Life history

Growth form: Shrub to 3 m high.
Vegetative spread: No.
Longevity:
Primary juvenile period: 2 years (Auld 1995), 4 years (Benson 1985).
Flowers: Red or coral pink, January–December, peak July–October. Bird-pollinated (Makinson 2000). New Holland and White-cheeked Honeyeaters obtain nectar from flowers (Armstrong 1991).
Fruit/seed: Capsule with 1–2 seeds; seeds with an elaiosome (lipid body) (Auld 1995), released at maturity, October–November; seed weight 27–34 mg (Morris 2000, Auld & Denham 1999, Westoby et al. 1990).
Dispersal, establishment & growth: Diaspore: seed, with food body ant-adapted for dispersal (Westoby et al. 1990, Rice & Westoby 1981). Soil-stored seedbank (Bradstock et al. 1997), initially with 88% dormancy, estimated half-life 3–4 years (Auld et al. 2000).
No breaking of seed dormancy by heating; strongly pulsed pattern of post-fire germination (Auld & Tozer 1995).
Germination experiment showed that: germination in untreated seeds c. 20%; germination mostly 30–40 days after treatment; germination commenced earlier in smoked seeds; smoke treatment increased amount of germination (x 1.7 with smoke alone); heat treatment; increase in germination with heat applied to smoked seeds but no increase with unsmoked seeds; significant increase in germination when scarification was used in addition to heat and smoke treatment; water uptake occurred rapidly in both scarified and unscarified seeds, mostly within 24 hrs and water loss was equally rapid on drying (Morris 2000), combined heat and smoke gave almost full germination, smoke having the most influence (Kenny 2000).
Fire response: Killed after high intensity fire 1/94 (at Lane Cove & Narrabeen Lake, P. Kubiak pers. comm.).
Interaction with other organisms: Small ants *Iridomyrmex* sp., *Pheidole* sp., *Crematogaster* sp. individuals working together move seed up to 20 cm and remove the elaiosome in pieces, or large solitary ants *Aphaenogaster* sp., *Thytidophonera* sp. may drag the seeds to their nests; thus, up to 20% of seed may escape predation by native mammals e.g. Bush Rat *Rattus fuscipes*, Swamp Wallaby *Wallabia bicolor* (Auld 1995, Auld & Denham 1999). Fungus *Placoasterella baileyi* causes a leaf spot disease (B. Summerell pers. comm.). Pre-dispersal seed predation 3% by weevils *Cydmaea dorsalis* and 1–13% by wasps *Eurytoma* sp. (Auld & Denham 2001b).

Distribution

Status/origin: Native.
Botanical subregions: CC.
Distribution Sydney area: Widespread north of Port Jackson (R. Makinson pers. comm.).
Select locations: CC: Kulnura, Bucketty, Narara, Maroota, Hornsby, Commodore Heights, Cheltenham, Frenchs Forest, Dee Why, Manly, Ryde, Northbridge, Rose Bay.

Habitat

Habitat: Ridgetops, hillsides.
Altitude: 0–200 m **Annual rainfall:** 1200–1400 mm
Typical local abundance: Frequent–occasional.
Vegetation: Woodland e.g. with *Angophora bakeri, A. costata, Corymbia gummifera, Eucalyptus punctata, E. racemosa, Syncarpia glomulifera.*
Substrate: Sandy soils on sandstone, low nutrients.
Exposure: Full sun to light shade.

Conservation

Conservation: Local endemic species, Port Jackson is southern geographical limit.
Reported from Marramarra NP, Ku-ring-gai Chase NP, Garigal NP, Sydney Harbour NP.

Grevillea sphacelata *(G. buxifolia* subsp. *sphacelata)* **PROTEACEAE**

Grey Spider Flower

Life history

Growth form: Shrub 0.4–2.5 m high, with silky branchlets and simple, narrow leaves and lignotuber (Makinson 2000), easily confused with *G. phylicoides* (R. Makinson pers. comm.).
Vegetative spread: No.
Longevity:
Primary juvenile period:
Flowers: Pale brown, June–December, peak September.
Fruit/seed: Slightly hairy capsule, with 1–2 seeds, weight 35 mg, released at maturity. Seed with food body (J. Howell pers. comm.).
Dispersal, establishment & growth: Diaspore: seed, ant-adapted for dispersal (Westoby et al. 1990).
Fire response: Resprouts (Morrison et al. 1995). ?Sometimes regenerates from a lignotuber (Makinson 2000).
Interaction with other organisms: Fungus *Placoasterella baileyi* causes a leaf spot disease (B. Summerell pers. comm.).

Distribution

Status/origin: Native.
Botanical subregions: CC CT .
Distribution Sydney area: Mainly Woronora Plateau.
Select locations: **CC**: Gladesville, Arncliffe, Randwick, Holsworthy, Engadine, Waterfall, Douglas Park, Appin, Bargo. **CT**: Colo Vale, Hill Top, Mittagong.

Habitat

Habitat: Woodland and heath.
Altitude: 0–600 m **Annual rainfall:** 900–1400 mm
Typical local abundance: Frequent.
Vegetation: Woodland e.g with *Eucalyptus sieberi, E. haemastoma, Corymbia gummifera, Angophora costata*; heath/scrub e.g. with *Banksia marginata, B. oblongifolia, B. spinulosa, Acacia suaveolens, Angophora hispida, Kunzea ambigua.*
Substrate: Shallow soils from sandstone, shaley clay or heavy loam.
Exposure: Full sun.

Conservation

Conservation: Conservation status unknown. Local endemic species, coastal from Port Jackson and Parramatta River to West Dapto and Mittagong (Makinson 2000). Reported in Royal NP.

Grevillea triternata PROTEACEAE

Life history

Growth form: Shrub 0.2–1 m high, with rhizome; leaves divided. Closely related to *G. raybrownii, G. ramosissima* (Makinson 2000).
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: White to cream or pale yellow, October.
Fruit/seed: Hairy capsule with reddish brown stripes or blotches and 1–2 winged seed, released at maturity, ?November.
Dispersal, establishment & growth: Diaspore: seed. Likely to have a food body for ant-dispersal (J. Howell pers. comm.).
Fire response: Probably reprouts from base.
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NT **CT** NWS CWS.
Distribution Sydney area: Blue Mountains and Bathurst area.
Select locations: **CT**: Widdin Valley, Growee, Winburndale NR, Bathurst, Mt Blaxland, Wanganderry.

Habitat

Habitat: Plateau.
Altitude: 400–800 m **Annual rainfall:** 600–700 mm
Typical local abundance: Occasional–frequent.
Vegetation: Woodland e.g. with *Eucalyptus fibrosa, E. punctata, E. sclerophylla, Hakea constablei, Callitris.*
Substrate: Gravelly clay to sandy soils on conglomerate, granite, sandstone, low nutrients.
Exposure: Full sun to light shade.

Conservation

Conservation: Conservation status unknown.

Hakea bakeriana PROTEACEAE

Life history

Growth form: Bushy, dense multistemmed low shrub 1–2 m high, with needle-like leaves 5–7 cm long; with a lignotuber.
Vegetative spread: No.
Longevity: Medium-long.
Primary juvenile period:
Flowers: Pink to crimson, on the main stem, May–September (Barker et al. 1999).
Fruit/seed: Rough, wrinkled woody fruit 50–70 mm long, with 2 winged seeds 38–55 mm long (Barker et al. 1999); canopy-stored seedbank.
Dispersal, establishment & growth: Diaspore: seed, gravity-dispersed or short distance wind-dispersed.
Fire response: Stems killed, resprouts from lignotuber. Flowers 2-3 years, fruits 4-5 years after fire (Aust Plants 8-295). Seedlings rare after fire.
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC **CC**.
Distribution Sydney area: Hornsby Plateau.
Select locations: **CC**: Morisset, Wyee, Wybung Head, Doyalson, Munmorah SRA, Kulnura, Maroota, Canoelands, Glenorie.

Habitat

Habitat: Ridges and hillsides.
Altitude: 0–300 m **Annual rainfall:** 1000–1400 mm
Typical local abundance: Occasional–frequent.
Vegetation: Woodland e.g. with *Angophora bakeri, Corymbia gummifera, Eucalyptus puncata, E. racemosa, E. capitellata*; heath e.g. with *Allocasuarina distyla, Lambertia formosa.*
Substrate: Sandy soils on sandstone, low nutrients.
Exposure: Light shade to full sun.

Conservation

Conservation: Restricted to near coastal area between Newcastle and Hawkesbury River (Barker et al. 1999), with southen geographical limit at Glenorie. Conservation status unknown. Reported from Dharug NP, Marramarra NP and Munmorah SRA.

Hakea constablei PROTEACEAE

Life history

Growth form: Slender to bushy shrub or small tree 2–6 m high, with hairy young growth and needle-like leaves 4–12 cm long.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Cream to white, October–November. September–November (Barker et al. 1999). Flowers on previous season's growth (Stacy 1977).
Fruit/seed: Warty, woody fruit 40–60 mm long, with 2 winged seeds. Oven-dried fruit weight 23.3 g, with one seed per fruit (Bradstock et al. 1994), seed 27–37 mm long (Barker et al. 1999). Fruits 5 cm diam, take up to 2 years to mature (Stacy 1977). Canopy-stored seedbank.
Dispersal, establishment & growth: Diaspore: seed, gravity-dispersed and short distance wind-dispersed. Seed with no dormancy mechanism (Bradstock et al. 1994). Relies on mist for moisture requirements (Stacy 1977).
Fire response: Plants killed (Barker et al. 1999). Exposure of fruits to increasing temperature (to 800 °C) does not adversely affect the viability of seed (Bradstock et al. 1994). May not regenerate well from seed following fire (Stacy 1977).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CC CT.
Distribution Sydney area: Upper Blue Mountains, Southern Highlands.
Select locations: CT: Mt Wilson, Mittagong, Bonnum Pic.

Habitat

Habitat: Rocky outcrops, cliffs.
Altitude: 500–1100 m **Annual rainfall:** 900–1200 mm
Typical local abundance: Frequent.
Vegetation: Heath and mallee e.g. with *Leptospermum trinervium, Banksia ericifolia, Acacia binervia, Eucalyptus apiculata.*
Substrate: Sandy soil or laterite on sandstone, low nutrients, well-drained.
Exposure: Full sun.

Conservation

Conservation: Local endemic confined to Blue Mountains and Southern Highlands, coded 2RCa on national rare species list (Briggs & Leigh 1996). Conservation adequacy unknown. Reported from Blue Mountains NP, Nattai NP.

Hakea dactyloides PROTEACEAE

Life history

Growth form: Erect, single-stemmed, non-lignotuberous shrub or small tree 2.5–4.5 m high, with simple flat leaves 5–14 mm wide. '*Hakea dactyloides* species complex' now divided into two species with the resprouting form recognised as *Hakea laevipes*; further resolution may follow as more information becomes available (Barker et al. 1999).
Vegetative spread: No.
Longevity: Medium (?15–28 years).

Primary juvenile period: 4 years (R. Lembit pers comm), 6.5 years after high intensity fire (1/1994) at Lane Cove (P. Kubiak pers. comm.).
Flowers: Cream, October–November. May show marked variation in amount of flowering from one year to the next (P. Kubiak pers. comm.). Honeybees, beetles and wasps attracted to flowers for ?nectar (P. Kubiak pers. comm.).

Fruit/seed: Woody, warty follicle 20–30 mm long, with 2 winged seeds 18–23 mm long; canopy-stored seedbank, released when death of branch or plant occurs. Oven-dried fruit weight 2.9–15.5 g (Bradstock et al. 1994). Seed viability 78.8% (Williams & Clarke 1998). In a field experiment highest germination rate was only 17.5%; waterlogging inhibits seed germination (Williams & Clarke 1997).
Dispersal, establishment & growth: Diaspore: seed, gravity or short distance wind-dispersed. May establish in absence of fire. Seedlings observed on disturbed sites (at Lithgow).
Fire response: Killed, re-establishes from seed released from follicles. Exposure of fruits to increasing temperatures decreases the viability of seed (Bradstock et al. 1994).
Interaction with other organisms: Low levels of pre-dispersal seed predation (Williams & Clarke 1997).

Distribution

Status/origin: Native.
Botanical subregions: **CC** SC **CT** ST CWS; Vic.
Distribution Sydney area: Widespread on coast and tablelands.
Select locations: **CC**: Kulnura, Gosford, Wisemans Ferry, Hornsby, Dee Why, Balls Head, Canterbury, Botany Bay, Cronulla, Nortons Basin, Woronora River, Royal NP, West Dapto, Springwood. **CT**: Clarence, Mt Wilson, Wentworth Falls, Katoomba, Kanangra Tops, Mittagong, Fitzroy Falls, Bundanoon, Wingello.

Habitat

Habitat: Slopes, ridges and along watercourses (Barker et al. 1999).
Altitude: 0–1200 m **Annual rainfall:** 800–1400 mm
Typical local abundance: Frequent.
Vegetation: Open-forest, gullies.
Substrate: Sandy soil on sandstone.
Exposure: Full sun.

Conservation

Conservation: Widespread and probably adequately conserved. Reported in Dharug NP, Royal NP, Blue Mountains NP.

Hakea dohertyi (*H.* sp. *B*) PROTEACEAE

Life history

Growth form: Slender shrub 3–4 m high, 3 m wide, with linear leaves 20–40 cm long; without a lignotuber. Stem circumference 30 cm above soil level to 39 cm (Steenbeeke 1995).
Vegetative spread: No.
Longevity: More than 100 years (Steenbeeke 1995).
Primary juvenile period: 7 years (Steenbeeke 1995).
Flowers: Creamy white, late August–late September (Steenbeeke 1995).

Fruit/seed: Woody fruit 25 mm long, with 2 winged seeds. Seed 12 mm long (Barker et al. 1999); canopy-stored seedbank. Seed predation in canopy 3–6%; canopy-stored seed highly viable 90–100% (Steenbeeke 1995).

Dispersal, establishment & growth: Diaspore: winged seed, gravity-dispersed, short-distance wind-dispersed. Protective mulch required for successful seedling recruitment; seed is dispersed at all times due to opening of the lower (older) follicles as a result of secondary thickening, althought peak dispersal is after a bushfire. Seedlings establish in the litter, and growth is initially very slow. Juvenile leaves are different to those of adults, being up to 10 cm long and 1 cm wide, and often covered in a closely appressed layer of rusty hairs. Unlike many *Hakea* species, this one occurs in populations having a wide representation of differently aged individuals; growth rate at least 10 cm per year (Steenbeeke 1995).

Fire response: Plants killed, regeneration from canopy-stored seed, seed killed with burning time more than 3 mins or temperature exceeding 300° C low intensity fast fire allows survival of seed-store; seedling recruitment continues in the absence of fire (Steenbeeke 1995).

Interaction with other organisms: Hover flies often seen around flower clusters, plant predators include scale insect, larva of butterfly *Papilio* sp. or *Graphium* sp., larvae of borers Coleoptera ; young plants eaten by goats (Steenbeeke 1995).

Distribution

Status/origin: Native.
Botanical subregions: CT.
Distribution Sydney area: Southern Blue Mountains.
Select locations: CT: Sombre Dome, Nercus Spur, Tonalli Point, Lake Burragorang, Irrae Gowar, Moonshine Hill, Rudders Rift.

Habitat

Habitat: Open, rocky ridgetops, often steep, dry, north facing sites.
Altitude: 100–1100 m **Annual rainfall:** 800–1000 mm
Typical local abundance:
Vegetation: Open-forest or woodland e.g. with *Eucalyptus punctata, E. sieberi, E. blaxlandii, Allocasuarina torulosa, Lomatia silaifolia, Stypandra glauca, Persoonia linearis.*

Substrate: Fine sandy soil with shale substrate, shallow sandy soil on rocky quartzite and shale in Lambie group (Devonian) or Kowmung Volcano clastics (Silurian), low nutrients.
Exposure: Withstands below-freezing temperatures. Full sun to light shade. Generally high exposure , under light shade and on crests of ridges or on north-facing slopes. Very rarely in heavy shade, and then showing spindly growth suggestive of stress (Steenbeeke 1995).

Conservation

Conservation: Local endemic species, mainly restricted to an area 18 km^2 in Kanangra Boyd NP, at least 7000 individuals (Steenbeeke 1995). Listed as Endangered (Schedule 1) NSW *Threatened Species Conservation Act 1995* and coded 2VCi on national rare species list (Briggs & Leigh 1996). Burragorang population threatened by possible increased storage level of lake.

Hakea gibbosa PROTEACEAE

Life history

Growth form: Shrub 1–3 m high, with hairy branchlets and hairy young needle-like leaves 2–8 cm long. No lignotuber (Barker et al. 1999).
Vegetative spread:
Longevity: ?20-30 years.
Primary juvenile period: 3 years after high intensity fire 1/94 (at Lane Cove, P. Kubiak pers. comm.).
Flowers: Yellowish white, on previous years growth. April–July (Barker et al. 1999).
Fruit/seed: Woody follicle 26–45 mm long, with winged seed 20–33 mm long; seed weight 64–71 mg (Westoby et al. 1990), may possibly release seed viable seed seasonally from underdeveloped fruit (Barker et al. 1999); canopy-stored seedbank, released after death of plant usually following fire. Oven-dried fruit weight 15.5 g, with one seed per fruit (Bradstock et al. 1994).
Dispersal, establishment & growth: Diaspore: seed, gravity or short distance wind-dispersed.
Fire response: Killed, re-establishes from canopy-stored seed. Exposure of fruits to increasing temperature (to 800°C) does not adversely affect the viability of seed (Bradstock et al. 1994).
Interaction with other organisms: Host plant of Cerambycid beetle *Aphanasium australe* (Hawkeswood 1993). Provides habitat for small nesting birds (Stacy 1977). Honeybees, hoverflies attracted to flowers for ?nectar; some plants with borers in tips of stems (P. Kubiak pers. comm.).

Distribution

Status/origin: Native.
Botanical subregions: CC SC.
Distribution Sydney area: Coast and adjacent plateaus.
Select locations: CC: Kulnura, Commodore Heights, Wahroonga, Cheltenham, Elanora, Brookvale, Chatswood, Manly, Dobroyd Point, Bondi, Arncliffe, Waterfall.

Habitat

Habitat: Most common in windswept scrub on coastal cliffs (Barker et al. 1999), ridges.
Altitude: 0–300 m **Annual rainfall:** 1100–1400 mm
Typical local abundance: Frequent.
Vegetation: Heath, woodland e.g. with *Corymbia gummifera, Leptospermum trinervium, Hakea teretifolia, Banksia ericifolia, Petrophile pulchella.*
Substrate: Sandy loam over sandstone, low nutrients.
Exposure: Full sun to light shade.

Conservation

Conservation: Reported from Bouddi NP, Brisbane Water NP, Marramarra NP, Ku-ring-gai Chase NP, Garigal NP, Lane Cove NP, Sydney Harbour NP. Probably adequately conserved.

Hakea laevipes subsp. *laevipes* (prev. included in *Hakea dactyloides*) PROTEACEAE

Life history

Growth form: Erect, bushy lignotuberous shrub 0.3–3 m high, with simple flat leaves 4–30 mm wide. '*Hakea dactyloides* species complex' now divided into two species with the resprouting form recognised as *Hakea laevipes*; further resolution may follow as more information becomes available (Barker et al. 1999).
Vegetative spread: No.
Longevity:
Primary juvenile period:
Flowers: Creamish, November–January. Flies, beetles and ants attracted to flowers for ?nectar (P. Kubiak pers. comm.).
Fruit/seed: Woody fruit 20–30 mm long, with 2 winged seeds 20 mm long; seed weight 18–27 mg (Westoby et al. 1990), canopy-stored seedbank, released when death of branch or plant occurs.

Dispersal, establishment & growth: Diaspore: seed, gravity-dispersed or short distance wind-dispersed.
Fire response: Stems killed, resprouts from lignotuber. Resprouted at Agnes Banks (Benson 1981).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC CC SC **CT** ST.
Distribution Sydney area: Widespread on coast and ranges.
Select locations: **CC**: Bucketty, Bilpin, Shane Park, Royal NP. **CT**: Newnes SF, Clarence, Wingello.

Habitat

Habitat: Ridges and slopes.
Altitude: 0–1000 m **Annual rainfall:** 800–1200 mm
Typical local abundance: Frequent–occasional.
Vegetation: Open-forest e.g. with *Angophora costata, Eucalyptus piperita*; woodland e.g. with *Eucalyptus haemastoma, E. sieberi, E. capitallata, Corymbia gummifera, Banksia serrata, B. spinulosa, Persoonia levis, Isopogon anemonifolius, Lomatia silaifolia*; mallee and heath e.g. with *Eucalyptus stricta, Petrophile pulchella, Banksia marginata, Phyllota squarrosa.*
Substrate: Sandy soils, on sandstone, Tertiary alluvium, low nutrients, sometimes poorly-drained.
Exposure:

Conservation

Conservation: Reported in Royal NP.

Hakea microcarpa PROTEACEAE

Small-fruited Hakea

Life history

Growth form: Spreading shrub to 2 m high, with needle-like leaves 3–11 cm long.
Vegetative spread: No.
Longevity:
Primary juvenile period:
Flowers: Whitish, December. September–February (Barker et al. 1999).
Fruit/seed: Woody follicle 15–17 mm long, with 2 winged seeds. Seed 7–12 mm long (Barker et al. 1999); canopy-stored seedbank. Seed viability 81.2% (Williams & Clarke 1997).
Dispersal, establishment & growth: Diaspore: seed, gravity or short distance wind-dispersed. Waterlogging inhibits germination (Williams & Clarke 1997).
Fire response: Resprouts from lignotuber (Williams & Clarke 1997).
Interaction with other organisms: Low levels of pre-dispersal seed predation (Williams & Clarke 1997). Fungus *Placoasterella baileyi* causes leaf spot disease (B. Summerell pers. comm.),

Distribution

Status/origin: Native.
Botanical subregions: SC NT **CT** ST NWS CWS; Qld, Vic., Tas.
Distribution Sydney area: Tablelands.
Select locations: **CT**: Mount Vincent, Newnes SF, Little Hartley, Turon River, Jenolan Caves, Oberon, Bowral, Penrose SF.

Habitat

Habitat: Wet places near creeks.
Altitude: 600–1200 m **Annual rainfall:** 800–900 mm
Typical local abundance: Frequent.
Vegetation: Wet heath and shrub swamp e.g. with *Leptospermum* sp., *Baeckea* sp. etc.
Substrate: Sandy soil on sandstone, low nutrients, poorly drained.
Exposure: Full sun.

Conservation

Conservation: Conservation status unknown.

Hakea pachyphylla (prev. included in *H. propinqua*) PROTEACEAE

Life history

Growth form: Compact to spreading, single-stemmed shrub to 2 m high, with branchlets ribbed and hairy, and needle-like leaves 1–5 cm long. No lignotuber (Barker et al. 1999).
Vegetative spread: No.
Longevity:
Primary juvenile period:
Flowers: Yellow, October. August–September (–October) (Barker et al. 1999).
Fruit/seed: Roundish woody follicle 29–35 mm long, with 2 winged seeds. Seed 22–25 mm long (Barker et al. 1999). Canopy-stored seedbank, released after death of branch or plant usually following fire.
Dispersal, establishment & growth: Diaspore: seed, gravity-dispersed or short distance wind-dispersed.
Fire response: Probably killed.
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CT ?SC.
Distribution Sydney area: Upper Blue Mountains.
Select locations: CT: Newnes SF, Du Faurs Rocks, Mt Wilson, Medlow, Kings Tableland.

Habitat

Habitat: Exposed sites, swampy areas or along creeks.
Altitude: 1000–1100 m **Annual rainfall:** 1000–1400 mm
Typical local abundance: Frequent.
Vegetation: Heath; wet heath; mallee heath e.g. with *Allocasuarina nana*.
Substrate: Skeletal sandy soil on sandstone, low nutrients.
Exposure: Full sun to light shade.

Conservation

Conservation: Local endemic species though possible occurrences in the Budawang Ranges need confirmation (Barker et al. 1999). Conservation status unknown.

Hakea propinqua PROTEACEAE

Life history

Growth form: Bushy shrub 1–2 m high, with needle-like leaves 2–8 cm long; without lignotuber. Often confused with *H. pachyphylla* (Barker et al. 1999).
Vegetative spread: No.
Longevity:
Primary juvenile period: Less than 3 years for a some, but more than 5 years for most plants after high intensity fire 1/94 (at Lane Cove, P. Kubiak pers. comm.).
Flowers: White–yellow, mainly August–December.
Fruit/seed: Woody fruit 30–40 mm long, very rough with acute wary protuberances, with winged seed. Seed 24–38 mm long (Barker et al. 1999). Canopy-stored seedbank, released after death of branch or plant usually following fire. Oven-dried fruit weight approximately 14–19 g, with one seed per fruit (Bradstock et al. 1994).
Dispersal, establishment & growth: Diaspore: seed, gravity-dispersed or short distance wind-dispersed. No seed dormancy (Bradstock et al. 1994).
Fire response: Killed after high intensity fire 1/94 (at Lane Cove & Narrabeen Lake, P. Kubiak pers. comm.). Exposure of fruits to increasing temperatures decreases the viability of seed (Bradstock et al. 1994).
Interaction with other organisms: Fungus *Placoasterella baileyi* causes a leaf spot disease (B. Summerell pers. comm.).

Distribution

Status/origin: Native.
Botanical subregions: CC CT.
Distribution Sydney area: Widespread Hornsby Plateau and Upper Blue Mountains.
Select locations: CC: Wollemi NP, Gosford, Maroota, Belrose, Bilpin. CT: Newnes SF, Mount Banks, Mt Victoria, Blackheath, Leura, Wentworth Falls, Hill Top.

Habitat

Habitat: Ridges, rocky plateaus.
Altitude: 0–1100 m **Annual rainfall:** 800–1400 mm
Typical local abundance: Frequent to occasional.
Vegetation: Open woodland e.g. with *Eucalyptus piperita, E. sclerophylla;* heath e.g. with *Allocasuarina nana, Banksia conferta, Boronia ledifolia, Lambertia formosa, Hakea teretifolia, Petrophile* sp., *Leptospermum* sp.
Substrate: Sand or sandy soil on sandstone, low nutrients, well-drained.
Exposure: Exposed to wind. Full sun.

Conservation

Conservation: Reported from Wollemi NP, Brisbane Water NP, Marramarra NP, Ku-ring-gai Chase NP, Garigal NP, Royal NP, Blue Mountains NP. Probably adequately conserved.

Hakea salicifolia subsp. *angustifolia* PROTEACEAE

Life history

Growth form: Tall slender shrub to 7 m high, with simple flat leaves 4–7 mm wide.
Vegetative spread: No.
Longevity:
Primary juvenile period:
Flowers: White, August–December. May possibly produce inflorescences from below leaves of previous ones (Barker et al. 1999).
Fruit/seed: Woody fruit 20 mm long, with 2 winged seeds. Seed 20 mm long. Canopy-stored seedbank.
Dispersal, establishment & growth: Diaspore: seed, gravity-dispersed or short distance wind-dispersed. Some seedlings seen 41 weeks after high intensity fire 1/94 (at Lane Cove, P. Kubiak pers. comm.).
Fire response: Probably killed by fire.
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CC.
Distribution Sydney area: Hornsby to Helensburgh.
Select locations: CC: Cockle and Cowan Creeks (Hornsby), Georges River, Casula, Lane Cove River, Woronora River (Heathcote), Flat Rock Creek (Helensburgh).

Habitat

Habitat: Creek banks and creekbeds.
Altitude: 0–100 m **Annual rainfall:** 1200–1400 mm
Typical local abundance: Frequent.
Vegetation: Riparian scrub e.g. with *Tristaniopsis laurina, Tristania neriifolia, Stenocarpus salignus, Lomandra fluviatilis.*
Substrate: Sandy alluvial soil on sandstone, low nutrients, periodically flooded.
Exposure: Full sun to mid shade.

Conservation

Conservation: Local endemic species, confined to river banks between Hornsby and Helensburgh (Barker et al. 1999). Reported in Lane Cove NP. Conservation adequacy unknown.

Hakea salicifolia subsp. *salicifolia* PROTEACEAE

Willow-leaved Hakea

Life history

Growth form: Tall shrub or small tree 2–5 m high, with simple flat leaves more than 7 mm wide.
Vegetative spread: No.
Longevity: 20–30 years?
Primary juvenile period: 6.5 years after high intensity fire (1/1994) at Lane Cove (P. Kubiak pers. comm.).
Flowers: White, September–November.
Fruit/seed: Woody fruit 20 mm long, with 2 winged seeds 20 mm long; canopy-stored seedbank.
Dispersal, establishment & growth: Diaspore: seed, gravity or short distance wind-dispersed.
Fire response: Killed, re-establishes from seed.
Interaction with other organisms: Small hairy caterpillars feed on leaves (P. Kubiak pers. comm.). Fungus *Placoasterella baileyi* causes a leaf spot disease (B. Summerell pers. comm.).

Distribution

Status/origin: Native.
Botanical subregions: NC CC SC NT CT.
Distribution Sydney area: Widespread.
Select locations: CC: Ku-ring-gai, Frenchs Forest, O'Hares Creek, Sublime Point, Tahmoor, Oakdale. CT: Nullo Mountain, Newnes SF, McMahons Lookout, Lawson, Fitzroy Falls.

Habitat

Habitat: Ridgetops, gullies, creek banks.
Altitude: 0–1200 m **Annual rainfall:** 900–1400 mm
Typical local abundance: Frequent.
Vegetation: Moist eucalypt open-forest e.g. with *Eucalyptus piperita, E. punctata, Corymbia gummifera, Angophora costata*; riparian scrub e.g. with *Callicoma serratifolia, Lomatia myricoides, Leptospermum polygalifolium.*
Substrate: Sandy loam on sandstone along creeks, medium nutrient soils.
Exposure:

Conservation

Conservation: Reported from Brisbane Water NP, Garigal NP, Lane Cove NP. Conservation adequacy unknown.

Hakea sericea PROTEACEAE

Life history

Growth form: Spreading bushy shrub to 4 m high, with needle-like leaves 2–5 cm long; without a lignotuber.
Vegetative spread: No.
Longevity: 15-20 years. Large plants 4 m high, died naturally in areas unburnt for 23 years at Elouera.
Primary juvenile period: 3 years (in cultivation). About 3–4 years after high intensity fire 1/94 (at Lane Cove, P. Kubiak pers. comm.).
Flowers: White, July–September, peak August, on previous years growth, insect-pollinated. Hoverflies, small native bees, and black beetles attracted to flowers probably for nectar (P. Kubiak pers. comm.).
Fruit/seed: Deeply wrinkled woody fruit 25–40 mm long, with 2 winged seeds released when death of branch or plant occurs. Seed 16–31 mm long (Barker et al. 1999); weight 39.1 mg ±1.4 (Hammill et al. 1998), 28–34 mg (Westoby et al. 1990). Oven-dried fruit weight 6.4 g (Bradstock et al. 1994).
Dispersal, establishment & growth: Diaspore: seed, gravity-dispersed or short distance wind-dispersed, rarely found more than a few yards from parents (Price 1979). No apparent dormancy mechanism, post-fire germination pattern appears to be related to rainfall events rather than season of burning (Whelan & York 1998). Seeds germinate 14–21 days (Cavanagh 1974) without treatment, and in absence of fire. Gregarious, often a coloniser of disturbed sites. Seedlings recorded in light gaps in areas unburnt for 20 years (Bradley, 1972) and 23 years (at Elouera).
Fire response: Killed after low intensity fire (Morrison et al. 1995), recruitment from canopy-stored seed. Recruitment following fire may not be very successful (Morrison 1995), exposure of fruit to increasing temperature decreases viability of seed (Bradstock et al. 1994). Following a spring fire more than 25% seeds germinated, with survival 5% of seedlings for next 1.5 years (Whelan & Tait 1995).
Interaction with other organisms: Host plant of Cerambycid beetles *Aphanasium australe, Aphanosperma occidentalis, Coptopterus arduus, C. scutellatus, Notoceresium impressiceps* (Hawkeswood 1993). Fungi *Placoasterella baileyi, Chactodiplodia* sp. cause leaf spot diseases (B. Summerell pers. comm.). Troublesome weed in Norfolk Is, New Zealand, S Africa (Barker et al. 1999).

Distribution

Status/origin: Native.
Botanical subregions: NC **CC** SC **CT** ST; Qld, *Vic.
Distribution Sydney area: Widespread
Select locations: **CC**: Maitland Bay, Glenorie, Marsden Park, Llandillo, Thornleigh, Chullora, Bangor, Waterfall. **CT**: Corricudgy, Mt Wilson, Hill Top, Berrima.

Habitat

Habitat: Slopes.
Altitude: 0–1000 m **Annual rainfall:** 800–1600 mm
Typical local abundance: Frequent.
Vegetation: Woodland e.g. with *Corymbia gummifera, Angophora costata, Eucalyptus punctata, E. fibrosa, Allocasuarina littoralis, Melaleuca decora, M. nodosa.*
Substrate: Sandy clay soil on sandstones, generally with lateritic or clay influence, also Tertiary alluvium and Wianamatta Shale. Low to medium-nutrient soils, periodically poorly-drained.
Exposure: Full sun to light shade.

Conservation

Conservation: Reported from Bouddi NP, Royal NP. Conserved in Western Sydney (James et al. 1999).

Hakea teretifolia (including subsp. *teretifolia* & subsp. *hirsuta*) PROTEACEAE

Life history

Growth form: Low spreading to erect much branched shrub to 4 m high, with needle-like leaves and hairy young branchlets. Two subspecies, subsp. *teretifolia* and subsp. *hirsuta* are recognised (Barker et al. 1999) but their distributions overlap.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: White or cream-white, November–February (Barker et al. 1999).
Fruit/seed: Woody fruit 16–27 mm long,with 2 winged seeds, retained on plant as canopy-stored seedbank. Seed weight 11.1 mg ± 0.4 (Hammill et al. 1998).
Dispersal, establishment & growth: Diaspore: seed, gravity or short distance wind-dispersed. Recruitment mainly after fire. Main growth period, December–June.
Fire response: Killed, re-establish from seed released from follicles. Seedlings establish within 9 months of fire with no further recruitment. Resprouting reported for plants at O'Hares Creek (D. Keith pers. comm.) although this may be a localised form (see separate record). *Hakea teretifolia* is generally killed by fire but some populations in the Sydney region produce lignotubers but it is not known whether this relates to a particular subspecies (Barker et al. 1999)
Interaction with other organisms: Fungi recovered from leaves: *Capnodium saliciunum, Phyllachora hakeae, Placoasterella baileyi* (B. Summerell pers. comm.). Shoot damage by rabbits but not eaten (P. Kubiak pers. comm.).

Distribution

Status/origin: Native.
Botanical subregions: NC **CC** SC **CT** ST; Vic., Tas.
Distribution Sydney area: Widespread.
Select locations: **CC**: Doyalson, Hornsby, Cheltenham, Lane Cove River, Maroubra, Arncliffe, Waterfall NP, Mt Ousley. **CT**: Mt Wilson, Leura, Robertson, Wingello.

Habitat

Habitat: Mainly coastal heath.
Altitude: 0–1000 m **Annual rainfall:** 900–1400 mm
Typical local abundance: Frequent.
Vegetation: Coastal heath e.g. with *Banksia ericifolia*; woodland e.g. with *Eucalyptus haemastoma, E. piperita, Corymbia gummifera.*
Substrate: Usually in wet or damp, sandy soil, on sandstone, low nutrients.
Exposure: Full sun.

Conservation

Conservation:

Helicia glabriflora PROTEACEAE

Life history

Growth form: Shrub or small tree to 10 m high, with leathery leaves 5–15 cm long.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Cream to pink, and blue, November–July.
Fruit/seed: Fleshy, dark blue, egg-shaped 12 mm diam. , with one seed, ripe June–November.
Dispersal, establishment & growth: Diaspore: fruit.
Fire response:
Interaction with other organisms: Fungus *Asterina* sp. causes a leaf spot (B. Summerell pers. comm.).

Distribution

Status/origin: Native.
Botanical subregions: NC **CC CT**; Qld.
Distribution Sydney area: North from Illawarra region.
Select locations: **CC**: Minnamurra Falls. **CT**: Robertson.

Habitat

Habitat: Rainforest.
Altitude: 0–700 m **Annual rainfall:** 1600–1800 mm
Typical local abundance: Rare.
Vegetation: Warm-temperate rainforest e.g. with *Acacia melanoxylon, Acmena smithii, Doryphora sassafras, Schizomeria ovata.*
Substrate: Clay soils on basalt, shale, high nutrients.
Exposure:

Conservation

Conservation: Sydney region population disjunct and confined to Minnamurra–Robertson area. Regionally rare in Illawarra region (Mills 1988). Minnamurra is southern geographical limit.

Isopogon anemonifolius PROTEACEAE

Drumsticks

Life history

Growth form: Shrub 1-1.5 m high, with divided leaves; multi-stemmed, with a lignotuber.
Vegetative spread:
Longevity: More than 60 years (D. Keith pers. comm.).
Primary juvenile period: More than 7 years (D. Keith pers. comm.).
Flowers: Yellow, July–January, peak October.
Fruit/seed: Hairy nut 2–3 mm long, weight 5 mg, in a woody cone 10–16 mm diam., retained on plant as canopy-stored seedbank.
Dispersal, establishment & growth: Diaspore: nut, gravity-dispersed, short distance wind-dispersed. Recruitment mainly after fire (D. Keith pers. comm.). Germination slow, up to 3 months, seedlings rarely observed.
Fire response: Stems killed, resprout from base in less than 2 months. Secondary juvenile period 2 years (Keith 1996). Minimum lignotuber size requried to survive a low intensity fire 2 cm diam; becomes fire-tolerant at more than 15 years old (Bradstock & Myerscough 1988). Population size is stable when interval between fire is 15 years for low intensity fires, or 16 years for high intensity fires (Bradstock & Auld 1987).
Interaction with other organisms: Small weevils seen on flower buds (P. Kubiak pers. comm.). Fungus *Vizella* sp. causes a leaf spot disease (B. Summerell pers. comm.).

Distribution

Status/origin: Native.
Botanical subregions: NC **CC** SC NT **CT** ST; Qld.
Distribution Sydney area: Widespread.
Select locations: **CC**: Wheeny Creek, Upper Colo, Castlereagh NR, Wilberforce, Maroota, Galston, Avalon, North Rocks, Centennial Park, Cooks River, Kurnell, Bundeena, Helensburgh, Bulli Pass, Springwood, Cambewarra, Bomaderry. **CT**: Clarence, Corricudgy, Newnes Plateau, Wentworth Falls, Blackheath, Mt Colong, Mittagong, Belmore Falls, Bundanoon, Wingello.

Habitat

Habitat: Ridgetops and open sites.
Altitude: 0–1200 m **Annual rainfall:** 800–1400 mm
Typical local abundance: Frequent.
Vegetation: Heath e.g. with *Banksia oblongifolia, B. paludosa, Kunzea ambigua, Allocasuarina torulosa,, Lambertia formosa, Petrophile pulchella;* open- forest e.g. with *Angophora costata, Corymbia gummifera, Eucalyptus haemastoma, Corymbia eximia, Eucalyptus sclerophylla, Angophora bakeri, Eucalyptus consideniana.*
Substrate: Sandy or sandy clay soils on sandstone, low nutrients.
Exposure: Full sun to light shade.

Conservation

Conservation: Reported from Wollemi NP, Bouddi NP, Brisbane Water NP, Ku-ring-gai Chase NP, Garigal NP, Blue Mountains NP, Royal NP, Castlereagh NR, Barren Grounds NR. A widespread well conserved species.

Isopogon anethifolius PROTEACEAE

Life history

Growth form: Erect shrub 1-3 m high.
Vegetative spread:
Longevity: Medium
Primary juvenile period:
Flowers: Yellow, mainly September–December, peak October.
Fruit/seed: Hairy nut 2–3 mm long, weight 4 mg, in a woody cone 12–25 mm diam., retained on plant as canopy-stored seedbank.
Dispersal, establishment & growth: Diaspore: nut, gravity-dispersed and short distance wind-dispersed. Seeds released after fire (J. Howell pers. comm.).
Fire response: Resprouts (D. Keith pers. comm.).
Interaction with other organisms: Small weevils feed destructively on flower buds (P. Kubiak pers. comm.). Fungus *Vizella* sp. causes a leaf spot disease (B. Summerell pers. comm.).

Distribution

Status/origin: Native.
Botanical subregions: **CC** SC **CT** ST.
Distribution Sydney area: widespread
Select locations: **CC**: Pearl Beach, Galston Gorge, Frenchs Forest, Cheltenham, Centennial Park, Leumeah, Wattamolla. **CT**: Coricudgy, Newnes SF, Mount Wilson, Kanangra, Wombeyan Caves, Bundanoon.

Habitat

Habitat: Rocky outcrops, ridges.
Altitude: 0–1200 m **Annual rainfall:** 900–1600 mm
Typical local abundance: Frequent.
Vegetation: Woodland e.g. with *Eucalyptus haemastoma, E. sieberi, E. sclerophylla*; heath e.g. with *Allocasuarina nana, Banksia ericifolia.*
Substrate: Sandy soil, low nutrients.
Exposure: Full sun to light shade.

Conservation

Conservation: Conserved in Western Sydney (James et al. 1999). Reported in Wollemi NP, Bouddi NP, Brisbane Water NP, Muogamarra Nature Reserve, Ku-ring-gai Chase NP, Garigal NP, Lane Cove NP, Sydney Harbour NP, Royal NP. Widespread, probably adequately conserved.

Isopogon dawsonii PROTEACEAE

Life history

Growth form: Erect shrub 1-3 m high, with hairy young branchlets and divided leaves.
Vegetative spread: No.
Longevity: Medium
Primary juvenile period:
Flowers: Creamy-yellowish, October.
Fruit/seed: Hairy nut 2–3 mm long in a woody cone 15–18 mm diam., retained on plant as canopy-stored seedbank.
Dispersal, establishment & growth: Diaspore: nut, gravity-dispersed.
Fire response: Plants killed, re-establish from seed released from burnt cones.
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: **CC** **CT** CWS.
Distribution Sydney area:
Select locations: **CC**: Glen Davis, Grose Vale, Glenbrook Creek, Nortons Basin. **CT**: Rylstone, Capertee, Lidsdale, Glowworm Tunnel.

Habitat

Habitat: Generally on sandstone ledges, cliffs, pagodas which may act as fire refuges.
Altitude: 0–1000 m **Annual rainfall:** 600–900 mm
Typical local abundance: Occasional.
Vegetation: Open-forest e.g. with *Eucalyptus punctata, E. piperita, Angophora costata, Syncarpia glomulifera, Eucalyptus crebra, E. eugenioides, Corymbia eximia;* heath e.g. with *Calytrix tetragona, Leucopogon muticus.*
Substrate: Skeletal soil on sandstone.
Exposure:

Conservation

Conservation: Conservation adequacy unknown. Reported from Wollemi NP.

Isopogon fletcheri PROTEACEAE

Life history

Growth form: Multi-stemmed shrub to 1.5 m high, with simple leaves.
Vegetative spread: No.
Longevity:
Primary juvenile period:
Flowers: Creamish green, September–December.
Fruit/seed: Nut 3 mm long, in a cone, retained on plant.
Dispersal, establishment & growth: Diaspore: nut, gravity-dispersed.
Fire response: Resprouts from base (R Coveny pers. comm.).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CT.
Distribution Sydney area: Blackheath.
Select locations: CT: Govetts Leap, Perrys Lookdown.

Habitat

Habitat: Wet cliff faces on escarpments.
Altitude: 600–1000 m **Annual rainfall:** 1200 mm
Typical local abundance: Rare–occasional.
Vegetation: Moist cliff vegetation e.g. with *Blandfordia cunninghamii, Goodenia decurrens, Dracophyllum secundum, Stylidium productum.*
Substrate: Sandstone, cliff-faces, low nutrients, permanent moisture.
Exposure: Sheltered.

Conservation

Conservation: Restricted local endemic coded 2VCat on national rare species list (Briggs & Leigh 1996). Confined to cliff faces at Blackheath, listed as Vulnerable (Schedule 2) NSW *Threatened Species Conservation Act 1995.*

Isopogon prostratus PROTEACEAE

Life history

Growth form: Prostrate shrub, sometimes more erect, with divided leaves.
Vegetative spread: Not capable of vegetative spread or rooting at nodes.
Longevity:
Primary juvenile period:
Flowers: Yellow, October–March.
Fruit/seed: Hairy nut 2–3 mm long on a woody cone 12–20 mm diam., retained on plant, sometimes covered by soil.
Dispersal, establishment & growth: Diaspore: nut, gravity-dispersed, short distance wind-dispersed. Resprouts from base after bulldozer damage.
Fire response: Probably resprouts.
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: SC CT ST; Vic.
Distribution Sydney area: Newnes Plateau, Penrose.
Select locations: CT: Newnes SF, Bald Trig, Tallong, Penrose SF.

Habitat

Habitat: Exposed situations.
Altitude: 600–1200 m **Annual rainfall:** 900–1000 mm
Typical local abundance: Rare.
Vegetation: Open-forest e.g. with *Eucalyptus mannifera, E. oreades;* heath e.g. with *Allocasuarina nana, Petrophile pulchella, Eucalyptus gregsoniana, E. stricta.*
Substrate: Sandy soil over sandstone.
Exposure: Full sun.

Conservation

Conservation: Rare, restricted to small localised populations. Conservation status unknown.

Lambertia formosa PROTEACEAE

Mountain Devil

Life history

Growth form: Shrub to 2 m high, with pungent-pointed leaves in whorls of 3 or 4–6.
Vegetative spread: No.
Longevity: More than 60 years (D. Keith pers. comm.).
Primary juvenile period:
Flowers: Red, 7 tubular flowers enclosed by bracts, at any time of year. Inflorescence density reaches peak 2-3 years after fire (Pyke 1983). Source of nectar for White-eared Honeyeater *Lichenostomus leucotis,* White-cheeked Honeyeater *Phylidonyris nigra* (Barker & Vestjens 1990). Small black ants, Noisy Miner *Manorina melanocephala* and New Holland Honeyeater *Phylidonyris ?novaehollandiae* feed on nectar (P. Kubiak pers. comm.).
Fruit/seed: Hard, beaked, horned woody fruit 15–25 mm long, with seed weight 17–26 mg, retained on plant.
Dispersal, establishment & growth: Diaspore: seed, with no special morphology for dispersal (Westoby et al. 1990). Recruitment mainly after fire (D. Keith pers. comm.). New resprouting growth is very sticky (L.McD.).
Fire response: Stems killed, resprouts from basal lignotuber. Secondary juvenile period 2 years (D. Keith pers. comm.).Tolerates repeated burning (A. Jelinek) but seedlings probably slow to establish.
Interaction with other organisms: Host to Cup Moth larvae *Mecytha fasciata* (Common 1990); larvae of moth *Xylorycta strigata* tunnel in the branches and feed on leaves (CSIRO 1991).

Distribution

Status/origin: Native.
Botanical subregions: NC **CC** SC **CT** ST.
Distribution Sydney area: Widespread
Select locations: **CC**: Putty, Norah Head, Kulnura, Kariong, Bowen Mountain, Wilberforce, Galston, Hornsby, Duffys Forest, Bantry Bay, La Perouse, Sutherland, Bundeena, Cataract, Springwood, Bomaderry. **CT**: Mt Wilson, Blackheath, Hill Top, Robertson, Bundanoon, Tallong.

Habitat

Habitat: Ridges, hillsides.
Altitude: 0–1100 mm **Annual rainfall:** 800–1400 mm
Typical local abundance: Frequent–occasional.
Vegetation: Heath e.g. with *Angophora hispida, Leptospermum trinervium, Banksia oblongifolia Banksia ericifolia*; open-forest and woodland e.g. with *Eucalyptus sieberi, Corymbia gummifera, Angophora costata, Angophora bakeri, Corymbia eximia, Eucalyptus sclerophylla, E. piperita.*
Substrate: Gravelly sand to sandy loam on sandstone, possibly with ironstone influence.
Exposure: Open sites, may have high light requirement.

Conservation

Conservation: Reported from Wollemi NP, Bouddi NP, Brisbane Water NP, Marramarra NP, Blue Mountains NP, Ku-ring-gai Chase NP, Garigal NP, Sydney Harbour NP, Royal NP. A widespread species, probably adequately conserved.

Lomatia ilicifolia PROTEACEAE

Life history

Growth form: Shrub to 3 m high, with rusty-hairy buds; leaves toothed.
Vegetative spread: Branches from underground stems.
Longevity: Indefinite.
Primary juvenile period:
Flowers: Creamy white, December–February. Flowering occurs on regrowth from the lignotuber in the first year after the previous shoot system has been destroyed by fire or other disturbance; although flowers may appear subsequently, they are usually smaller (Weston & Crisp 1994).
Fruit/seed: Leathery fruit 20–30 mm long, with several flat winged seeds, weight 16 mg, with yellow powder, released at maturity, mainly September–January.
Dispersal, establishment & growth: Diaspore: seed, wind-dispersed locally (Westoby et al. 1990).
Fire response: Stems killed, resprouts from lignotuber (R Lembit pers. comm.). Secondary juvenile period 1 year (Weston & Crisp 1994).
Interaction with other organisms: Fungus *Periconiella telopeae* causes a leaf spot disease (B. Summerell pers. comm.).

Distribution

Status/origin: Native.
Botanical subregions: SC **CT** ST; Vic.
Distribution Sydney area: Southern Highlands.
Select locations: **CT**: Moss Vale, Robertson, Paddys River, Belmore Falls, Fitzroy Falls, Bundanoon, Wingello, Abercrombie River.

Habitat

Habitat: Open-forest.
Altitude: 600–700 m **Annual rainfall:** 900–1000 mm
Typical local abundance: Frequent.
Vegetation: Open-forest e.g. with *Eucalyptus sieberi, E. piperita, E. quadrangulata, Lambertia formosa.*
Substrate: Sandy loam over sandstone, low nutrients, well-drained.
Exposure:

Conservation

Conservation: Moss Vale is northern geographical limit. Conservation status unknown.

Lomatia myricoides PROTEACEAE

River Lomatia

Life history

Growth form: Shrub or small tree 2–7 m high. Occasionally hybridizes with *L. silaifolia* where they grow together (P. Weston pers. comm.).
Vegetative spread: No.
Longevity: Probably long.
Primary juvenile period:
Flowers: Greenish yellow to creamy white or pale pink, December–February. Flies and small ants feed on nectar (P. Kubiak pers. comm.).
Fruit/seed: Leathery fruit 20–30 mm long, green, turning black on maturity with several flat winged seeds, with yellow powder, released at maturity, mainly September–January.
Dispersal, establishment & growth: Diaspore: seed, wind-dispersed locally.
Fire response: Resprouts from base (R. Lembit pers. comm.).
Interaction with other organisms: Fungi recovered from leaves: *Brefeldiella* sp., *Chactothyrium* sp., *Meliola lanosa, Periconiella telopeae* (B. Summerell pers. comm.).

Distribution

Status/origin: Native.
Botanical subregions: **CC** SC **CT** ST CWS; Vic.
Distribution Sydney area: Widespread.
Select locations: **CC**: Dharug NP, Narrara, Pennant Hills, Mosman (1892), Casula, Woronora River, Cobbitty, Tahmoor. **CT**: Coricudgy, Clarence, Mt Wilson, Lawson, Kanangra Walls, Mt Werong, Mittagong, Robertson, Wombeyan Caves.

Habitat

Habitat: Creeks, watercourses, with permanent moisture, montane forest.
Altitude: 0–1200 m **Annual rainfall:** 700–1400 mm
Typical local abundance: Frequent.
Vegetation: Riverbank forest e.g. with *Tristaniopsis laurina, Backhousia myrtifolia, Acacia elata, Ceratopetalum apetalum, Leptospermum polygalifolium, Gleichenia dicarpa*, or as understorey in montane open-forest e.g. with *Eucalyptus mannifera, E. dives, Brachyloma daphnoides, Monotoca scoparia* e.g. Montane Moist Forest of Keith and Benson 1988.
Substrate: Sandy alluvium from sandstone or moist loamy soil from basalt, low to high nutrients.
Exposure: Sheltered sites.

Conservation

Conservation: Widespread species with northern geographical limit at Mt Coricudgy. Adequately conserved. Reported in Brisbane Water NP, Dharug NP, Marramarra NP, Muogamarra Nature Reserve, Ku-ring-gai Chase NP, Garigal NP, Lane Cove NP.

Lomatia silaifolia PROTEACEAE

Crinkle Bush

Life history

Growth form: Shrub 1–2 m high, with lignotuber. Extremely variable in the amount of dissection in the leaves and the degree of glaucousness (Harden 1991). Occasionally hybridizes with *L. myricoides* where they grow together (P. Weston pers. comm.).
Vegetative spread: No.
Longevity: More than 60 years (D. Keith pers. comm.).
Primary juvenile period:

Flowers: White, November–January. Flowers abundantly only after fire (Keith 1996). Flowering is confined to the post-fire period, mostly in the second summer following fire; partially self-compatible, only 25% of self-pollinated flowers initiating fruit, compared to 100% of cross-pollinated flowers; probably insect-pollinated — most visits by beetles and ants, with no birds, moths or butterflies observed; up to 14% of flowers undamaged by herbivory produce fruit (Denham & Whelan 2000). Possibly pollinated by large flies (P. Kubiak pers. comm.). Fewer viable seeds (22%) produced from self-pollinated flowers than from cross-pollinated flowers (62%); 7–14 seeds per fruit (Denham & Whelan 2000).

Fruit/seed: Leathery fruit 30–50 mm long, with several flat winged seeds released at maturity, February–May. Yellow powder observed on mature seeds — ?does it inhibit seed predation or fungus (P. Kubiak pers. comm.).
Dispersal, establishment & growth: Diaspore: seed, wind-dispersed (Westoby et al. 1990), no dormancy mechanism (Denham & Whelan 2000), recruitment mainly after fire. Seed germination related to seed mass, with viable seeds weighing more than 7 mg (Denham & Whelan 2000).
Fire response: Stems killed, resprouts from lignotuber within 2 months of fire (Bradley, 1972). Secondary juvenile period 1 year; flowering occurs on regrowth from the lignotuber in the first year after the previous shoot system has been destroyed by fire or other disturbance; although flowers may appear subsequently, they are usually smaller (Weston & Crisp 1994)
Interaction with other organisms: Fungus *Stenella lomatiae* causes a leaf spot disease (B. Summerell pers. comm.). Substantial herbivory of flowering branches by mammals, probably wallaby *Wallabia bicolor*; also damage to flowers by invertebrates e.g. grasshoppers and larvae of moths or butterflies (Denham & Whelan 2000).

Distribution

Status/origin: Native.
Botanical subregions: NC **CC** NT **CT** NWS CWS; Qld.
Distribution Sydney area: Widespread.
Select locations: **CC**: Howes Valley, Kulnura, Wisemans Ferry, Maroota, Duffys Forest, Long Bay, Oatley, La Perouse, Oakdale, Wedderburn, Helensburgh. **CT**: Nullo Mountain, Newnes SF, Katoomba, Jenolan Caves, Kanangra Walls, Bowral, Barren Grounds.

Habitat

Habitat: Ridges and gullies.
Altitude: 0–1200 m **Annual rainfall:** 800–1400 mm
Typical local abundance: Frequent.
Vegetation: Open-forest e.g. *Corymbia gummifera, Syncarpia glomulifera, E. pilularis, Eucalyptus agglomerata, E. piperita, Angophora costata, E. punctata, E. sclerophylla, Allocasuarina torulosa, Eucalyptus macrorhyncha, E. radiata.*
Substrate: Sandy soils on sandstone, granite, slates, low nutrients.
Exposure:

Conservation

Conservation: Widespread and well conserved. Reported in Bouddi NP, Brisbane Water NP, Marramarra NP, Muogamarra Nature Reserve, Ku-ring-gai Chase NP, Dalrymple Hay Nature Reserve, Garigal NP, Sydney Harbour NP, Royal NP.

Persoonia acerosa PROTEACEAE

Life history

Growth form: Erect to spreading shrub with narrow leaves channelled on upper surface. Occasionally hybridises with *P. levis, P. myrtilloides* and *P. linearis* where they grow together.
Vegetative spread: No.
Longevity:
Primary juvenile period:
Flowers: Yellow, sweetly scented, December–April, peak January.
Fruit/seed: Fleshy fruit, with one seed enclosed in a hard, woody stone, dull green to yellow when ripe, shed at maturity, October–November.
Dispersal, establishment & growth: Diaspore: fruit, probably dispersed by large birds e.g. Currawongs (Buchanan 1989), possibly dispersed by large, mammals, kangaroos, possums; soil-stored seedbank, germination triggers unknown (P. Weston pers. comm.).
Fire response: Probably killed (P. Weston pers. comm.).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CC CT.
Distribution Sydney area: Blue Mountains.
Select locations: CC: Valley Heights. CT: Newnes Plateau, Mt Wilson, Mt Victoria, Blackheath, Katoomba, Kings Tableland, Hazelbrook, Hill Top.

Habitat

Habitat: Ridges, rock outcrops.
Altitude: 400–1100 m **Annual rainfall:** 900–1400 mm
Typical local abundance: Rare to occasional.
Vegetation: Eucalypt open-forest e.g. with *Eucalyptus sclerophylla, E. sieberi, E. piperita, E. sparsifolia, Angophora costata*; heath e.g. with *Eucalyptus stricta*.
Substrate: Clayey to sandy soils on sandstone, low nutrients.
Exposure: Full sun to light shade (P. Weston pers. comm.).

Conservation

Conservation: Listed as Vulnerable (Schedule 2) NSW *Threatened Species Conservation Act 1995*. Coded 2VC- on national rare species list (Briggs & Leigh 1996). Recorded for Blue Mountains NP.

Persoonia acuminata (*P. nutans* subsp. *C* in part) PROTEACEAE

Life history

Growth form: Prostrate to spreading shrub to 1.7 m high, with hairy young branchlets. Apparently intergrades with *P. oxycoccoides* in a limited area between Jenolan Caves and Kanangra Walls (Weston & Johnson 1991).
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Yellow, December–April (Weston & Johnson 1991).
Fruit/seed: Fleshy green fruit, with one seed enclosed in a hard, woody stone, shed at maturity.
Dispersal, establishment & growth: Diaspore: fruit, probably dispersed by large birds e.g. Currawongs (Buchanan 1989), possibly dispersed by large mammals, kangaroos, possums; soil-stored seedbank, germination triggers unknown (P. Weston pers. comm.).
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NT CT.
Distribution Sydney area: Hampton area.
Select locations: CT: Hampton, Mt Bindo, Jenolan Caves, Belarah Swamp, Kanangra Walls.

Habitat

Habitat: Hillsides.
Altitude: 1000–1200 m **Annual rainfall:** 900–1000 mm
Typical local abundance: Frequent–occasional.
Vegetation: Eucalypt woodland or open-forest e.g. with *Eucalyptus radiata, E. dalrympleana, E. sieberi, E. stricta, E. mannifera.*
Substrate: Well-drained soils, usually derived from granite or metasediments, or on basic volcanic substrates (Weston & Johnson 1991), low to high nutrients.
Exposure: Full sun to light shade (P. Weston pers. comm.).

Conservation

Conservation: Conservation adequacy unknown though not considered rare (Weston & Johnson 1991). Reported in Kanangra-Boyd NP.

Persoonia bargoensis (split from *P. nutans*) PROTEACEAE

Life history

Growth form: Erect shrub 0.6–2.5 m high, with hairy young branchlets.
Vegetative spread: No.
Longevity:
Primary juvenile period:
Flowers: Yellow, December–January (Weston & Johnson 1991).
Fruit/seed: Fleshy green fruit, with one seed enclosed in a hard, woody stone. Fruit shed at maturity.
Dispersal, establishment & growth: Diaspore: fruit, probably dispersed by large birds e.g. Currawongs (Buchanan 1989), possibly dispersed by large mammals, kangaroos, possums; soil-stored seedbank, germination triggers unknown (P. Weston pers. comm.).
Fire response: Probably killed (P. Weston pers. comm.).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CC.
Distribution Sydney area: Douglas Park to Bargo.
Select locations: CC: Douglas Park, Wilton, Bargo, Yanderra.

Habitat

Habitat: Woodland to open-forest.
Altitude: 100–300 m **Annual rainfall:** 900–1000 mm
Typical local abundance: Rare–occasional.
Vegetation: Open-forest e.g. with *Eucalyptus tereticornis, E. fibrosa*, and grassy *Themeda australis* understorey; woodland e.g. with *Corymbia gummifera, Eucalyptus sclerophylla, E. punctata, E. sparsifolia, Angophora bakeri*, and shrubby understorey e.g. with *Pultenaea elliptica.*
Substrate: Clayey soil on intergrading areas Hawkesbury Sandstone and Wianamatta Shale (Mittagong formation) (Weston & Johnson 1991), low to medium nutrients.
Exposure: Full sun to light shade (P. Weston pers. comm.).

Conservation

Conservation: Local endemic restricted to the Bargo area, listed as Endangered (Schedule 1) NSW *Threatened Species Conservation Act 1995*. Coded 2V on national rare species list (Briggs & Leigh 1996).

Persoonia chamaepeuce PROTEACEAE

Life history

Growth form: Prostrate shrub with narrow leaves. Often forms extensive rhizomes (P. Weston pers. comm.).
Vegetative spread: Suckering from rootstock.
Longevity:
Primary juvenile period:
Flowers: Yellow, December–January. Long-tongue bees *Leioproctus (Filiglossa)* sp. forage on flowers (Bernhardt & Weston 1996), *Leioproctus filamentosa* forages on the flowers (Bernhardt & Walker 1996), probably not effective pollinators (P. Weston pers. comm.).
Fruit/seed: Fleshy fruit green with maroon striations, with one seed enclosed in a hard, woody stone. Fruit shed at maturity.
Dispersal, establishment & growth: Diaspore: fruit, probably dispersed by large birds e.g. Currawongs (Buchanan 1989), possibly dispersed by large mammals, kangaroos, possums; soil-stored seedbank, germination triggers unknown (P. Weston pers. comm.).
Fire response: Probably resprouts from rootstock and rhizomes (P. Weston pers. comm.).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NT CT ST; Vic.
Distribution Sydney area: Tablelands.
Select locations: CT: Orange, Hargraves, Sunny Corner, Upper Kowmung.

Habitat

Habitat: Hillsides.
Altitude: 800–1200 m **Annual rainfall:** 700–1000 mm
Typical local abundance: Occasional.
Vegetation: Eucalypt open-forest and woodland e.g. with *Eucalyptus radiata, E. sieberi, E. pauciflora, E. oreades, E. dives*, with shrubby understorey.
Substrate: Sandy soil on sandstone, granites and metasediments, not on limestones, low nutrients.
Exposure:

Conservation

Conservation: Uncommon species occurring sporadically. Conservation status unknown.

Persoonia chamaepitys PROTEACEAE

Life history

Growth form: Prostrate shrub forming mats often exceeding 1m diameter, with hairy young branchlets.
Vegetative spread: No nodal rooting or vegetative spread.
Longevity:
Primary juvenile period:
Flowers: Yellow, occasionally with reddish markings (P. Weston pers. comm.), November–December. Long-tongue bees *Chalicodoma* sp., *Hylaeus* sp. and *Eumenid* wasp forage on flowers but only long-tongue bee *Leioproctus raymenti* carried pollen (Bernhardt & Weston 1996).
Fruit/seed: Fleshy fruit whitish with red striations, with one seed enclosed in a hard, woody stone. Fruit shed at maturity.
Dispersal, establishment & growth: Diaspore: fruit, probably dispersed by large birds e.g. Currawongs (Buchanan 1989), possibly dispersed by large mammals, kangaroos, possums; soil-stored seedbank, germination triggers unknown (P. Weston pers. comm.). Often along roadsides and may be a light-requiring coloniser.
Fire response: Killed by fire (P. Weston pers. comm.).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CC CT CWS.
Distribution Sydney area: Colo area and higher parts of Blue Mountains and adjacent valleys.
Select locations: CC: Mellong Range, Colo Heights. CT: Coricudgy, Newnes SF, Clarence, Mount Victoria, Blackheath, Narrow Neck, Kings Tableland, Wingello.

Habitat

Habitat: Plateaus, slopes and near swamps.
Altitude: 300–1200 m **Annual rainfall:** 800–1400 mm
Typical local abundance: Frequent–occasional.
Vegetation: Open-forest and woodland e.g. with *Eucalyptus dives, E. radiata, E. sclerophylla, E. sieberi, E. piperita, Corymbia gummifera.*
Substrate: Sandy soils and sandy alluvium, low nutrients.
Exposure: Full sun to light shade (P. Weston pers. comm.).

Conservation

Conservation: Reported from Blue Mountains NP, Wollemi NP. Status of disjunct population at Wingello (last collected 1917) unknown. Recent collections from the Budawangs (P. Weston pers. comm.).

Persoonia glaucescens (*P. lanceolata* subsp. *B*) **PROTEACEAE**

Life history

Growth form: Erect shrub, with hairy young branchlets.
Vegetative spread: No.
Longevity:
Primary juvenile period:
Flowers: Orange–yellow, January–May. Insects foraging on flowers include *Apis mellifera, Callomelitta* sp. *Exoneura* sp. but only long-tongue bees *Leioproctus (Cladocerapis) carinatifrons, L. incanescens, L. speculiferus* carried (Bernhardt & Weston 1996).
Fruit/seed: Fleshy fruit green suffused with purple, with one seed enclosed in a hard, woody stone. Fruit shed at maturity, September–December.
Dispersal, establishment & growth: Diaspore: fruit, probably dispersed by large birds e.g. Currawongs (Buchanan 1989), possibly dispersed by large mammals, kangaroos, possums; soil-stored seedbank, germination triggers unknown (P. Weston pers. comm.).
Fire response: Killed by fire (P. Weston pers. comm.).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CC CT.
Distribution Sydney area: Picton to Berrima.
Select locations: CC: Thirlmere, Buxton. CT: Hill Top, Welby, Berrima, Kangaloon, Fitzroy Falls.

Habitat

Habitat: Ridgetops and slopes.
Altitude: 400–700 m **Annual rainfall:** 900 mm
Typical local abundance: Occasional.
Vegetation: Woodland; open-forest e.g. with *Eucalyptus piperita, E. sieberi, E. sparsifolia, E. sclerohylla, E. punctata, Corymbia gummifera*, with shrubby understorey.
Substrate: Sandy clay soil on sandstone, low nutrients.
Exposure: Full sun to light shade (P. Weston pers. comm.).

Conservation

Conservation: Local endemic species listed as Vulnerable (Schedule 2) NSW *Threatened Species Conservation Act 1995*. Coded 2V on national rare species list (Briggs & Leigh 1996).

Persoonia hindii PROTEACEAE

Life history

Growth form: Erect to spreading multi-stemmed shrub to 1 m high, with narrow succulent leaves that become concave when dried. Most closely resembles *P. chamaepeuce*.
Vegetative spread: Shoots arise from extensive rhizomes which lie 5 cm below the soil surface (Weston & Johnson.
Longevity: Indefinite.
Primary juvenile period:
Flowers: Deep yellow, January to March.
Fruit/seed: Dull green, succulent, fleshy fruit (drupe), with one seed enclosed in a hard, woody stone. Fruit shed at maturity.
Dispersal, establishment & growth: Diaspore: fruit, probably dispersed by large birds e.g. Currawongs (Buchanan 1989), possibly dispersed by large mammals, kangaroos, possums; soil-stored seedbank, germination triggers unknown (P. Weston pers. comm.). Seedling recruitment rate appears to be extremely low (Weston & Johnson 1997).
Fire response: Probably resprouts from rhizomes.
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CT.
Distribution Sydney area: Newnes Plateau, near Lithgow.
Select locations: CT: Sunnyside Road, Newnes SF, State Mine Creek.

Habitat

Habitat: Plateaus and slopes.
Altitude: 1130–1170 m **Annual rainfall:** 900–1000 mm
Typical local abundance: Rare.
Vegetation: Eucalypt open-forest and woodland 'Newnes Plateau Woodland' (Benson & Keith 1990) e.g. with *Eucalyptus sieberi, E. radiata, E. dives, E. pauciflora, E. oreades, E. gullickii* and shrubby understorey e.g. with *Daviesia latifolia, Phyllota squarrosa, Lomatia silaifolia, Polyscias sambucifolia.*
Substrate: Sandy soils from Narrabeen Sandstone, low nutrients, well-drained (Weston & Johnson 1997).
Exposure: Full sun to light shade (P. Weston pers. comm.).

Conservation

Conservation: Rare local endemic, known from only 6 small populations each no more than 100 m wide and each possibly consisting of a single clone; a more detailed survey of the distribution of *P. hindii* is needed for management in Newnes State Forest (Weston & Johnson 1997). Listed as Endangered (Schedule 1) NSW *Threatened Species Conservation Act 1995.* Proposed code 2V on national rare species list of Briggs and Leigh 1996 (Weston & Johnson 1997), not conserved and threatened by sand mining.

Persoonia hirsuta subsp. *evoluta* PROTEACEAE

Life history

Growth form: Spreading to decumbent, shrub, with hairy young branchlets. The subspecies intergrade extensively from the lower Blue Mountains to within 15 km of the coast (Weston & Johnson 1991), hybridizes with *P. mollis* subsp. *nectens* (P. Weston pers. comm.).
Vegetative spread: No.
Longevity:
Primary juvenile period:
Flowers: Yellow, very strongly sweetly scented (P. Weston pers. comm.), September–January.
Fruit/seed: Fleshy fruit green to cream with red streaks, rarely uniformly dark purple (P. Weston pers. comm.). with one seed enclosed in a hard, woody stone. Fruit shed at maturity.
Dispersal, establishment & growth: Diaspore: fruit, dispersed by large birds e.g. Currawongs (Buchanan 1989), possibly dispersed by large mammals, kangaroos, possums; soil-stored seedbank, germination triggers unknown (P. Weston pers. comm.).
Fire response: Probably killed by fire (P. Weston pers. comm.).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CC CT.
Distribution Sydney area: Sporadic.
Select locations: CC: Putty, Glen Davis, Springwood, Bargo. CT: Balmoral, Hill Top.

Habitat

Habitat: Ridges.
Altitude: 300–600 m **Annual rainfall:** 700–900 mm
Typical local abundance: Rare–frequent.
Vegetation: Open-forest to woodland e.g. with *Eucalyptus sclerophylla, E. sparsifolia, E. punctata, E. sieberi, Corymbia gummifera, Persoonia levis, Acacia* sp., *Eriostemon australasius.*
Substrate: Sandy loam on Hawkesbury Sandstone, low nutrients.
Exposure: Full sun to light shade (P. Weston pers. comm.).

Conservation

Conservation: Local endemic taxon, conservation status not known. Possibly vulnerable (P. Weston pers. comm.).

Persoonia hirsuta subsp. *hirsuta* PROTEACEAE

Life history

Growth form: Spreading to decumbent, shrub, with hairy young branchlets. The subspecies intergrade with subsp. *evoluta* extensively from the lower Blue Mountains to within 15 km of the coast (Weston & Johnson 1991).
Vegetative spread: No.
Longevity:
Primary juvenile period:
Flowers: Yellow, mainly November–January.
Fruit/seed: Fleshy fruit, with one seed enclosed in a hard, woody stone. Fruit shed at maturity.
Dispersal, establishment & growth: Diaspore: fruit, probably dispersed by large birds e.g. Currawongs (Buchanan 1989), possibly dispersed by large mammals, kangaroos, possums; soil-stored seedbank, germination triggers unknown (P. Weston pers. comm.).
Fire response: Probably killed.
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CC.
Distribution Sydney area: Coast, Gosford to Royal NP.
Select locations: CC: Gosford, Cowan, Wahroonga, Turramurra, Roseville, Manly, North Head, Oatley, Jannali, Royal NP.

Habitat

Habitat: Sides of ridges, often on disturbed sites such as quarries.
Altitude: 0–300 m **Annual rainfall:** 1200–1600 mm
Typical local abundance: Rare.
Vegetation: Heath, scrub or woodland.
Substrate: Sandy to stony soils from sandstone, low nutrients.
Exposure: Full sun to light shade (P. Weston pers. comm.).

Conservation

Conservation: Local endemic subspecies, listed as Endangered (Schedule 1) NSW *Threatened Species Conservation Act 1995*, coded 3KCi on national rare species list (Briggs & Leigh 1996). No known conservation sites and now found as single plants or groups of less than 10. Many old collection sites now destroyed. Many herbarium collections made before 1920, suggesting it may have been more common then.

Persoonia isophylla (sp. aff. *pinifolia*) PROTEACEAE

Life history

Growth form: Erect to spreading shrub 0.3–1.5 m high, with hairy young branchlets; closely resembles *P. pinifolia* but no hybrids reported (Weston & Johnson 1991).
Vegetative spread: No.
Longevity:
Primary juvenile period:
Flowers: Yellow, December–June, peak March. Long-tongue bee *Leioproctus (Cladocerapis) speculiferus* is the dominant species foraging on flowers; others foragers include *Apis mellifera, Hyaleus* sp. *Lasioglossum brazieri, Leioproctus (Filiglossa)* sp., *L. speculiferus, Nomia* sp., Sphecid wasps (Bernhardt & Weston 1996), *Leioproctus filamentosa* (Bernhardt & Walker 1996).

Fruit/seed: Fleshy, green with purple sufusion, with one seed enclosed in a hard woody stone, shed at maturity, August–December.
Dispersal, establishment & growth: Diaspore: fruit, probably dispersed by large birds e.g. Currawongs (Buchanan 1989), possibly dispersed by large mammals, kangaroos, possums; soil-stored seedbank, germination triggers unknown (P. Weston pers. comm.). Appears to be coloniser of disturbed sites.
Fire response: Killed (P. Weston pers. comm.).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CC.
Distribution Sydney area: Gosford–Kulnura to Manly.
Select locations: CC: Boree Track, Kulnura, Gosford, Bouddi NP, Patonga Creek, McCarrs Creek, Terrey Hills.

Habitat

Habitat: Heathy sites. Edges of walking/vehicular tracks (L.McD.).
Altitude: 0–250 m **Annual rainfall:** 1200 mm
Typical local abundance: Occasional–frequent.
Vegetation: Woodland e.g. with *Corymbia gummifera, Eucalyptus sieberi, E. haemastoma, Banksia serrata, Petrophile pulchella, Leptospermum trinervium, Hakea sericea*; heath e.g. with *Angophora hispida.*
Substrate: Sand or sandy soil on sandstone, low nutrients, well-drained.
Exposure: Full sun to light shade.

Conservation

Conservation: Local endemic species, likely to be adequately conserved. Reported in Yengo NP, Bouddi NP, Brisbane Water NP, Ku-ring-gai Chase NP.

Persoonia lanceolata PROTEACEAE

Life history

Growth form: Erect to spreading shrub 1–3.5 m high, with hairy young branchlets; leaves 3–10 cm long. Occasionally hybridizes with *P. linearis* (Weston 1991).
Vegetative spread: No.
Longevity: 25–60 years (D. Keith pers. comm.), present in bush unburnt for 13 years (at Field Mars).
Primary juvenile period: Primary juvenile period more than 6 years (D. Keith pers. comm.). About 3 years after high intensity fire 1/94 (at Lane Cove, P. Kubiak pers. comm.).

Flowers: Yellow, mainly January–May. Probably pollinated by native bees (P. Kubiak pers. comm.). Long-tongue bees *Leioproctus (Cladocerapis) carinatifrons, L. incanescens, L. speculiferus* collect nectar and/or pollen from the flowers; other insect foragers include *Leioproctus (Filiglossa)* sp., *Exoneura* sp. (Bernhardt & Weston 1996), *Leioproctus filamentosa* forages on the flowers (Bernhardt & Walker 1996).
Fruit/seed: Fleshy fruit, mean fresh weight 1300 mg (Westoby et al. 1990), with two or rarely one seed enclosed in a hard, woody stone. Fruit shed at maturity, peak September–October.

Dispersal, establishment & growth: Diaspore: fruit, adapted for vertebrate dispersal (Westoby et al. 1990). Probably dispersed by large birds e.g. Currawongs (Buchanan 1989), Seed eaten by foxes (Myall Lakes), possibly dispersed by large mammals, kangaroos, possums; soil-stored seedbank, germination triggers unknown (P. Weston pers. comm.). Recruitment mainly after fire. Re-establishes naturally on areas after sand mining between Budgewoi and Toukley where it is common. Recolonised mined areas at Bonny Hills (Clark, 1975) with higher cover than pre-mining. ? Indicative of disturbance.

Fire response: Killed and re-establishes from soil-stored seedbank (Fox 1988).
Interaction with other organisms: Fungi *Anthracostroma persooniae, Camarosporula persooniae* cause leaf spot disease (B. Summerell pers. comm.).

Distribution

Status/origin: Native.
Botanical subregions: NC **CC** SC **CT** ST.
Distribution Sydney area: Mainly coastal.
Select locations: **CC**: Norah Head, Somersby, Cheltenham, Belrose, Manly, Bondi, Long Bay, Kurnell, Heathcote, Waterfall, Appin, Dapto, Warrimoo. **CT**: Hill Top, Belanglo.

Habitat

Habitat: Ridgetops, slopes.
Altitude: 0–700 m **Annual rainfall:** 900–1400 mm
Typical local abundance: Occasional–frequent.
Vegetation: Open-forest e.g. with *Eucalyptus sclerophylla, E. piperita, E. sieberi, E. sparsifolia, E. punctata, Corymbia gummifera*, shrubby understorey e.g. with *Lambertia formosa, Leptospermum trinervium, Daviesia corymbosa , Banksia ericifolia, Banksia serrata*; woodland; heath e.g. with *Banksia ericifolia, B. oblongifolia, Darwinia fascicularis*; also sea cliff-top scrub.
Substrate: Sand or sandy loam on sandstone, low nutrients, well-drained.
Exposure: Full sun to light shade (P. Weston pers. comm.).

Conservation

Conservation: Adequately conserved (P. Weston pers. comm.). Reported in Bouddi NP, Brisbane Water NP, Marramarra NP, Ku-ring-gai Chase NP, Lane Cove NP, Sydney Harbour NP, Botany Bay NP.

Persoonia laurina subsp. *intermedia* (*P. laurina* subsp. *B*) PROTEACEAE

Life history

Growth form: Erect to spreading multi-stemmed shrub; leaves mostly opposite, mature leaves scabrous.
Vegetative spread: No.
Longevity:
Primary juvenile period:
Flowers: Yellow and white, November–January, peak December.
Fruit/seed: Fleshy fruit, fresh weight 1100–1550 mg (Westoby et al. 1990), with one seed enclosed in a hard, woody stone. Fruit shed at maturity, July–October.
Dispersal, establishment & growth: Diaspore: fruit, adapted for vertebrate dispersal (Westoby et al. 1990), probably dispersed by large birds e.g. Currawongs (Buchanan 1989), possibly dispersed by large mammals, kangaroos, possums; soil-stored seedbank, germination triggers unknown (P. Weston pers. comm.).
Fire response: Resprouts from lignotuber.
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CC CT.
Distribution Sydney area: Woronora Plateau.
Select locations: CC: Leumeah, Cataract River, Thirlmere, Yerrinbool. CT: Hill Top, Mittagong, Robertson, Wombeyan Caves.

Habitat

Habitat: Ridges.
Altitude: 0–620 m **Annual rainfall:** 700–1000 mm
Typical local abundance: Frequent.
Vegetation: Open-forest e.g. with *Corymbia gummifera, Eucalyptus sparsifolia, E. sclerophylla, E. punctata, E. sieberi, E. piperita, E. smithii.*
Substrate: Sandy loam on sandstone, Tertiary sediments, low nutrients, well-drained.
Exposure: Full sun to light shade (P. Weston pers. comm.).

Conservation

Conservation: Local endemic taxon, conservation status unknown.

Persoonia laurina subsp. *laurina* (*P. laurina* subsp. *A*) PROTEACEAE

Life history

Growth form: Erect to spreading shrub; leaves mostly opposite, mature leaves smooth.
Vegetative spread: Root suckering may be possible in some populations (C. Nancarrow pers. comm.).
Longevity: 50–100 years.
Primary juvenile period:
Flowers: Yellow and white, November–February, peak December. Long-tongue bee *Leioproctus (Cladocerapis)* sp. collects nectar and/or pollen from the flowers (Bernhardt & Weston 1996).
Fruit/seed: Fleshy fruit, with one seed enclosed in a hard, woody stone. Fruit shed at maturity, June–December, peak September.
Dispersal, establishment & growth: Diaspore: fruit, adapted for vertebrate dispersal (Westoby et al. 1990), probably dispersed by large birds e.g. Currawongs (Buchanan 1989), possibly dispersed by large mammals, kangaroos, possums; soil-stored seedbank, germination triggers unknown (P. Weston pers. comm.).

Fire response: Stems killed, sometimes resprouts from lignotuber. Secondary juvenile period less than 3 years after high intensity fire 1/94 (at Lane Cove, P. Kubiak pers. comm.).
Interaction with other organisms: Fungus *Camarosporula persooniae* causes a leaf spot disease (B. Summerell pers. comm.).

Distribution

Status/origin: Native.
Botanical subregions: NC CC CT.
Distribution Sydney area: Coast and Blue Mountains.
Select locations: **CC**: Morisset, Maroota, Agnes Banks, Llandilo, Castle Hill, Hornsby, Beecroft, Peakhurst, Kemps Creek. **CT**: Capertee, Clarence, Mt Victoria, Blackheath, Katoomba, Woodford.

Habitat

Habitat: Ridges.
Altitude: 0–1100 m **Annual rainfall:** 700–1400 mm
Typical local abundance: Occasional–frequent.
Vegetation: Woodland e.g. with *Eucalyptus haemastoma, Angophora bakeri, Eucalyptus sieberi, E. sclerophylla*; heath e.g. with *Banksia ericifolia, Allocasuarina nana.*
Substrate: Sandy loam on sandstone, Wianamatta Shale, Tertiary sand deposits, low to medium nutrient soils.
Exposure: Full sun to light shade (P. Weston pers. comm.).

Conservation

Conservation: Southern geographical limit is Georges River. Conservation status unknown. Reported in Marramarra NP, Ku-ring-gai Chase NP, Garigal NP, Lane Cove NP.

Persoonia laurina subsp. ***leiogyna*** (*P. laurina* subsp. *C*) **PROTEACEAE**

Life history

Growth form: Erect to spreading shrub; leaves mostly opposite, mature leaves scabrous.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Yellow, September–December.
Fruit/seed: Fleshy fruit, with one seed enclosed in a hard, woody stone. Fruit shed at maturity, August–December.
Dispersal, establishment & growth: Diaspore: fruit, adapted for vertebrate dispersal (Westoby et al. 1990), probably dispersed by large birds e.g. Currawongs (Buchanan 1989), possibly dispersed by large mammals, kangaroos, possums; soil-stored seedbank, germination triggers unknown (P. Weston pers. comm.).
Fire response: Resprouts from lignotuber (P. Weston pers. comm.).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: SC CT ST.
Distribution Sydney area: Tablelands south from Jenolan.
Select locations: **CT**: Oberon, Jenolan Caves, Kanangra, Mt Werong, Berrima, Wombeyan Caves, Carrington Falls, Wingello.

Habitat

Habitat: Rocky hillsides.
Altitude: 550–1000 m **Annual rainfall:** 1000–1200 mm
Typical local abundance: Frequent–occasional.
Vegetation: Open-forest e.g. with *Eucalyptus sieberi, E. piperita, E. radiata, E. cinerea, Allocasuarina torulosa*; shrubby understorey.
Substrate: Shallow sandy soils on sandstone, granite, quartzite/igneous rocks, low nutrients, poorly-drained.
Exposure: Full sun to light shade (P. Weston pers. comm.).

Conservation

Conservation: Northern geographical limit is Oberon. Conservation status unknown.

Persoonia laxa *(P. nutans* subsp. *B)* **PROTEACEAE**

Life history

Growth form: Decumbent or prostrate shrub with hairy young branchlets. Specimen collected from Dee Why (1922) could be hybrid with *P. levis* (Weston & Johnson 1991).
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Yellow, November–January? (Weston & Johnson 1991).
Fruit/seed: Fruit unknown but most probably a drupe like all other persoonias (P. Weston pers. comm.).
Dispersal, establishment & growth: Diaspore: fruit, probably dispersed by large birds e.g. Currawongs (Buchanan 1989), possibly dispersed by large mammals, kangaroos, possums; soil-stored seedbank, germination triggers unknown (P. Weston pers. comm.).
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CC.
Distribution Sydney area: Newport–Manly.
Select locations: CC: Newport (1907), Manly (1908).

Habitat

Habitat:
Altitude: 0–20 m **Annual rainfall:** 1200–1400 mm
Typical local abundance:
Vegetation: Open-forest, woodland, heath.
Substrate:
Exposure:

Conservation

Conservation: Local endemic listed as Presumed Extinct under NSW *Threatened Species Conservation Act 1995*, coded 2X on national rare species list (Briggs & Leigh 1996). Known from only 2 collections, Manly, Newport in developed suburban areas.

Persoonia levis PROTEACEAE

Broad-leaved Geebung

Life history

Growth form: Erect to spreading shrub or small tree, with loose flaky bark. Occasionally hybridizes with *P. acerosa, P. linearis, P. mollis* subsp. *ledifolia, P. myrtilloides* and *P. oxycoccoides*.
Vegetative spread: No.
Longevity: More than 60 years (D. Keith pers. comm.).
Primary juvenile period:
Flowers: Yellow, mainly September–February, peak December–January. Long-tongue bee *Leioproctus (Cladocerapis) carinatifrons* collects nectar and/or pollen from the flowers (Bernhardt & Weston 1996).
Fruit/seed: Fleshy fruit, mean fresh weight 1700 mg (Westoby et al. 1990), with one or two seeds enclosed in a hard, woody stone. Fruit shed at maturity.

Dispersal, establishment & growth: Diaspore: fruit, adapted for vertebrate dispersal (Westoby et al. 1990), probably dispersed by large birds e.g. Currawongs (Buchanan 1989), possibly dispersed by large mammals, kangaroos, possums; soil-stored seedbank, germination triggers unknown (P. Weston pers. comm.). Recruitment mainly after fire (D. Keith pers. comm.). Germination after lying in sand and leaf litter for 12 months (S. Fisher pers. comm.).

Fire response: Stems killed and regenerates with basal sprouts (D. Keith pers. comm.). Vigorous resprouting from all of the trunk (c. 8 cm diam.) following very high intensity fire at Bantry Bay 12/1990 (L.McD.). May fruit 4 years after fire (Bradley 1972), 1 year after high intensity fire 1/94 (at Lane Cove, P. Kubiak pers. comm.).
Interaction with other organisms: Fungus *Anthracostroma persooniae* causes a leaf spot disease (B. Summerell pers. comm.).

Distribution

Status/origin: Native.
Botanical subregions: NC **CC** SC **CT** ST; Vic.
Distribution Sydney area: Widespread.
Select locations: **CC**: Gosford, Pymble, Chowder Head, O'Hares Creek, La Perouse, Kurnell, Waterfall, Springwood, Bargo, Minnamurra Falls. **CT**: Mt Coricudgy, Mt Wilson, Katoomba, Wombeyan Caves, Carrington Falls.

Habitat

Habitat: Ridges and slopes.
Altitude: 0–1100 m **Annual rainfall:** 900–1400 mm
Typical local abundance: Frequent–occasional.
Vegetation: Open-forest and woodland e.g. with *Eucalyptus piperita, E. sieberi, E. sclerophylla, Corymbia gummifera, Eucalyptus radiata, E. smithii, Angophora costata.*
Substrate: Sandy soils on sandstone, low nutrients, well-drained.
Exposure: Full sun to light shade (P. Weston pers. comm.).

Conservation

Conservation: Adequately conserved. Reported in Wollemi NP, Bouddi NP, Brisbane Water NP, Marramarra NP, Blue Mountains NP, Ku-ring-gai Chase NP, Garigal NP, Lane Cove NP, Sydney Harbour NP, Botany Bay NP, Budderoo NP.

Persoonia linearis PROTEACEAE

Narrow-leaved Geebung

Life history

Growth form: Erect shrub or small tree, with flaky bark reddish beneath surface. Occasionally hybridizes with *P. acerosa, P. levis, P. mollis* subsp. *ledifolia, P. myrtilloides* and *P. oxycoccoides.*
Vegetative spread: Limited suckering from roots (up to 8 m from adult) exposed by disturbance (observed at Elderslie).
Longevity:
Primary juvenile period:
Flowers: Yellow, December–July, peak January–February. Probably pollinated by native bees (P. Kubiak pers. comm.).
Fruit/seed: Fleshy fruit green with maroon stripes or rarely green, mean fresh weight 1900 mg (Westoby et al. 1990), with one or two seeds enclosed in a hard, woody stone. Fruit shed at maturity, September–November.
Dispersal, establishment & growth: Diaspore: fruit, adapted for vertebrate dispersal (Westoby et al. 1990), probably dispersed by large birds e.g. Currawongs (Buchanan 1989), possibly dispersed by large mammals, kangaroos, possums; soil-stored seedbank, germination triggers unknown (P. Weston pers. comm.).
Fire response: Resprouts from lignotuber and epicormics on stem greater than 2 cm diameter.
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC CC SC NT CT ST CWS; Vic.
Distribution Sydney area: Widespread.
Select locations: CC: Putty, Howes Valley, Wisemans Ferry, Morisset, Ourimbah, Bobbin Head, Cheltenham, Manly, Oatley, Bilpin, Campbelltown, Picton, Bargo, Cambewarra.
CT: Mt Coricudgy, Portland, Capertee, Lithgow, Blackheath, Kowmung, Yerranderie, Mt Jellore, Wombeyan Caves, Fitzroy Falls, Bundanoon.

Habitat

Habitat:
Altitude: 0–1000 m **Annual rainfall:** 700–1400 mm
Typical local abundance: Frequent–occasional.
Vegetation: Woodland, open-forest e.g. with *Angophora costata, Eucalyptus sieberi, E. piperita, E. aggomerata, E. pilularis, E. paniculata, E. saligna, E. sparsifolia, E. rossii* with shrubby understorey.
Substrate: Sandy soil on sandstone, low nutrients, well-drained.
Exposure: Full sun to light shade.

Conservation

Conservation: Widespread and adequately conserved. Reported in Bouddi NP, Brisbane Water NP, Marramarra NP, Ku-ring-gai Chase NP, Garigal NP, Lane Cove NP, Sydney Harbour NP.

Persoonia marginata PROTEACEAE

Life history

Growth form: Spreading to decumbent shrub with hairy young branches.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Yellow, December.
Fruit/seed: Fleshy green fruit, with two seeds enclosed in a hard, woody stone. Fruit shed at maturity.
Dispersal, establishment & growth: Diaspore: fruit, probably dispersed by large birds e.g. Currawongs (Buchanan 1989), possibly dispersed by large mammals, kangaroos, possums; soil-stored seedbank, germination triggers unknown (P. Weston pers. comm.).
Fire response: Resprouts [Herbarium specimen]
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CT.
Distribution Sydney area: Confined to Capertee district.
Select locations: CT: Clandulla SF, Capertee, Dark Corner.

Habitat

Habitat: Ridges and slopes.
Altitude: 700–800 m **Annual rainfall:** 600–700 mm
Typical local abundance: Rare–occasional.
Vegetation: Open-forest e.g. with *Eucalyptus rossii, E. beyeriana, E. tenella* with grassy/shrubby understorey.
Substrate: Sandy clay and gravelly soil, low nutrients.
Exposure:

Conservation

Conservation: Restricted local endemic, listed as Vulnerable (Schedule 2) under NSW *Threatened Species Conservation Act 1995* and coded 2V on national rare species list (Briggs & Leigh 1996).

Persoonia microphylla PROTEACEAE

Life history

Growth form: Prostrate to erect shrub to 2 m high, with hairy young branchlets. Grows sympatrically with *P. laurina* subsp. *intermedia* and subsp. *leiogyna*; occasionally hybridises with *P. mollis* subsp. *livens* where they grow together (Weston & Johnson 1991).
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Yellow, February. Flowers sporadically throughout the year (Weston & Johnson 1991).
Fruit/seed: Fleshy fruit green with purple stripes, with one seed; with four cotyledons (Weston & Johnson 1991), shed at maturity, October.
Dispersal, establishment & growth: Diaspore: fruit, probably dispersed by large birds e.g. Currawongs (Buchanan 1989), possibly dispersed by large mammals, kangaroos, possums; soil-stored seedbank, germination triggers unknown (P. Weston pers. comm.).
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CT ST.
Distribution Sydney area: Southern Blue Mountains.
Select locations: CT: Mount Werong, Wombeyan Caves.

Habitat

Habitat:
Altitude: 900–1200 m **Annual rainfall:** 800–1000 mm
Typical local abundance: Frequent.
Vegetation: Open-forest e.g. with *Eucalyptus viminalis.*
Substrate: Stony, sandy to clayey soil from sandstone or other siliceous rocks (Weston & Johnson 1991), low nutrients.
Exposure: Full sun to light shade (P. Weston pers. comm.).

Conservation

Conservation: Mt Werong is northern geographical limit. Conservation status unknown.

Persoonia mollis subsp. *caleyi* PROTEACEAE

Life history

Growth form: Erect to prostrate shrub, with hairy young branchlets.
Vegetative spread: No.
Longevity:
Primary juvenile period:
Flowers: Yellow, buds in December.
Fruit/seed: Fruit with one seed, shed at maturity.
Dispersal, establishment & growth: Diaspore: fruit, probably dispersed by large birds e.g. Currawongs (Buchanan 1989), possibly dispersed by large mammals, kangaroos, possums; soil-stored seedbank, germination triggers unknown (P. Weston pers. comm.).
Fire response: Killed (Krauss 1997).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: SC CC.
Distribution Sydney area: Kangaroo Valley.
Select locations: CC: Tallowa Dam.

Habitat

Habitat: Roadside, disturbed edge of open-forest.
Altitude: 100–200 m **Annual rainfall:** 1200 mm
Typical local abundance: Frequent.
Vegetation: Eucalypt open-forest.
Substrate: Clay-influenced soil from Shoalhaven Group.
Exposure: Full sun to light shade (P. Weston pers. comm.).

Conservation

Conservation: Recently recorded near Bendeela Picnic Area, Tallowa Dam, the only record for CC and the northern geographical limit. Conservation adequacy unknown.

Persoonia mollis subsp. *ledifolia* PROTEACEAE

Life history

Growth form: Erect shrub, with hairy young branchlets.
Vegetative spread: No.
Longevity:
Primary juvenile period:
Flowers: Yellow, January–February. Long-tongue bees *Leioproctus* (*Cladocerapis*) collect nectar and/or pollen from the flowers (Bernhardt & Weston 1996).
Fruit/seed: Fleshy fruit, with one seed enclosed in a hard, woody stone, shed at maturity, October–November.
Dispersal, establishment & growth: Diaspore: fruit, probably dispersed by large birds e.g. Currawongs (Buchanan 1989), possibly dispersed by large mammals, kangaroos, possums; soil-stored seedbank, germination triggers unknown (P. Weston pers. comm.).
Fire response: Killed (Krauss 1997).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CC CT.
Distribution Sydney area: Southern Highlands.
Select locations: CC: Berry. CT: Robertson, Carrington Falls, Fitzroy Falls, Bundanoon, Penrose, Wingello.

Habitat

Habitat: Plateaus, hillsides.
Altitude: 600–700 m **Annual rainfall:** 900–1600 mm
Typical local abundance: Occasional–frequent.

Vegetation: Open-forest e.g. with *Eucalyptus radiata, E. piperita, E. smithii, E. sieberi, Corymbia gummifera*; woodland e.g. with *Eucalyptus sieberi, E. piperita, Banksia paludosa, Persoonia levis, P. oxycoccoides.*
Substrate: Sandy soil on sandstone, low nutrients.
Exposure: Full sun to light shade (P. Weston pers. comm.).

Conservation

Conservation: Local endemic, adequacy of conservation unknown. Recorded for Morton NP, Barren Grounds Nature Reserve, Budderoo NP.

Persoonia mollis subsp. *leptophylla* PROTEACEAE

Life history

Growth form: Erect shrub to 1.5 m high, with hairy young branchlets.
Vegetative spread: No.
Longevity:
Primary juvenile period:
Flowers: Yellow, mainly January–March.
Fruit/seed: Fleshy fruit, with one seed enclosed in a hard, woody stone. Fruit shed at maturity.
Dispersal, establishment & growth: Diaspore: fruit. Probably dispersed by large birds e.g. Currawongs (Buchanan 1989), possibly dispersed by large mammals, kangaroos, possums; soil-stored seedbank, germination triggers unknown (P. Weston pers. comm.). Possibly colonises locally bared sites
Fire response: Killed (Krauss 1997).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CC SC ST.
Distribution Sydney area: Nowra.
Select locations: CC: Bomaderry, Nowra.

Habitat

Habitat: Woodland.
Altitude: 0–200 m **Annual rainfall:** 1400 mm
Typical local abundance: Frequent.
Vegetation: Woodland e.g. with *Corymbia gummifera, Eucalyptus piperita, E. consideniana, Kunzea ambigua, Leptospermum sejunctum, Acacia obtusifolia, Lambertia formosa*; heathy scrub e.g. with *Allocasuarina, Banksia ericifolia, Leptospermum trinervium, Kunzea ambigua.*
Substrate: Sandy and clayey to gravelly loam over sandstone, low nutrients.
Exposure: Full sun.

Conservation

Conservation: Bomaderry is northern geographical limit, conservation status unknown.

Persoonia mollis subsp. *livens* PROTEACEAE

Life history

Growth form: Erect shrub to 1.5 m high, with hairy young branchlets and narrow grey-green leaves with a hairy lower surface.
Vegetative spread: No.
Longevity:
Primary juvenile period:
Flowers: Yellow, mainly January.
Fruit/seed: Fleshy fruit, with one seed enclosed in a hard, woody stone. Fruit shed at maturity.
Dispersal, establishment & growth: Diaspore: fruit, probably dispersed by large birds e.g. Currawongs (Buchanan 1989), possibly dispersed by large mammals, kangaroos, possums; soil-stored seedbank, germination triggers unknown (P. Weston pers. comm.).
Fire response: Killed (Krauss 1997).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CT ST.
Distribution Sydney area: Penrose–Wingello.
Select locations: CT: Paddys River, Penrose, Wingello SF, Barbers Creek, Tallong.

Habitat

Habitat: Ridgetop, upper hillside.
Altitude: 500–700 m **Annual rainfall:** 900–1000 mm
Typical local abundance: Occasional.
Vegetation: Open-forest to woodland e.g. with *Eucalyptus rossii, E. mannifera, E. cinerea, E. sclerophylla, Allocasuarina littoralis, Banksia spinulosa, Platysace lanceolata, Pomaderris ligustrina.*
Substrate: Brown sandy loam from metasediments, conglomerate, sandstone, low nutrients.
Exposure: Light shade.

Conservation

Conservation: Penrose is northern geographical limit. Conservation status unknown.

Persoonia mollis subsp. *maxima* PROTEACEAE

Life history

Growth form: Erect shrub to 6 m high, with copper-coloured hairs on flower buds, young branchlets, and young leaves.
Vegetative spread: No.
Longevity:
Primary juvenile period: Probably reaches peak flowering and fruiting at 10–15 years (NPWS 1999).
Flowers: Yellow, December–March; pollinated by native bees, mostly *Leioproctus* and *Exoneura* species; the European Honey Bee forages actively on the pollen and nectar but is probably not an effective pollinator; approximately 20% cross-pollinated flowers set fruit compared with 1% of self-pollinated flowers (NPWS 1999).

Fruit/seed: Fleshy fruit dull pink to purple at maturity, with one seed enclosed in a hard, woody stone. Drops to the ground when ripe, November–December. Seedbank stored in the leaf litter layer of the soil profile (NPWS 1999).

Dispersal, establishment & growth: Diaspore: fruit, may be dispersed by floodwaters along creeklines (P. Kubiak pers. comm.). Seed dispersal may be supplemented by small mammals and birds; seed germination may be chemically inhibited with dormancy broken by passing through the gut of small mammals (NPWS 1999). Soil-stored seedbank, germination triggers unknown (P. Weston pers. comm.).

Fire response: Killed (Krauss 1997). Populations aged less than 8 years are extremely vulnerable to local extinction (NPWS 1999).
Interaction with other organisms: Seed predation by Cockatoos, Rosellas and possibly possums, small native rats, and some reptiles (NPWS 1999).

Distribution

Status/origin: Native.
Botanical subregions: CC.
Distribution Sydney area: Cowan to Hornsby.
Select locations: CC: Berowra Valley, Mt Kuring-gai, Galston Creek, Asquith, Hornsby.

Habitat

Habitat: Sheltered hillsides and moist gullies, mostly with a southerly aspect. Flood-prone habitat along creeks (P. Kubiak pers. comm.).
Altitude: 50–150 m **Annual rainfall:** 1200 mm
Typical local abundance: Rare–frequent.
Vegetation: Open-forest e.g. with *Angophora costata, Eucalyptus piperita, E. punctata, Leionema dentatum, Isopogon anethifolius, Ceratopetalum gummiferum, Hakea salicifolia, Gleichenia, Pultenaea flexilis, Grevillea linearifolia*; creekside scrub e.g. with *Bauera rubioides, Acrotriche divaricata, Ceratopetalum apetalum, Callicoma serratifolia.*

Substrate: Sandy soil from Hawkesbury Sandstone, low nutrients, well-drained.
Exposure: Sheltered, light shade to medium shade, but will tolerate full sun. Able to tolerate flooding (P. Kubiak pers. comm.).

Conservation

Conservation: Local endemic taxon listed as Endangered (Schedule 1) NSW *Threatened Species Conservation Act 1995,* coded 2E on national rare species list (Briggs & Leigh 1996). Restricted to Hornsby Heights–Mt Colah–Mt Kuring-gai area with a north-south range 5.75 km; total population size 550 adult plants (NPWS 1999). Relatively recent range contraction (Krauss 1997) threatened by inappropriate fire regime, urban run-off, sedimentation of creek lines, weeds, and loss of opportunity for cross-pollination with fragmentation, isolation of populations and loss of native bee pollinators (NPWS 1999). Reported in Ku-ring-gai Chase NP.

Persoonia mollis subsp. *mollis* PROTEACEAE

Life history

Growth form: Erect to prostrate shrub, with hairy young branchlets.
Vegetative spread: No.
Longevity:
Primary juvenile period:
Flowers: Yellow, December–April. Long-tongue bees *Leioproctus (Cladocerapis) carinatifrons, L. incanescens, L. speculiferus* collect nectar and/or pollen from the flowers; other insect foragers include Coleoptera: *Zonitis* sp., Hymenoptera: *Amegilla* sp., *Apis mellifera, Chalicodoma* sp., *Exoneura* sp., *Homalictus urbanus, Lasioglossum repraesentans, Leioproctus bipectinatus, L. (Filiglossa)* sp., *Nomia* sp., Ichneumonid wasp (Bernhardt & Weston 1996).
Fruit/seed: Fleshy fruit, with two seeds enclosed in a hard, woody stone, shed at maturity, August–November.
Dispersal, establishment & growth: Diaspore: fruit, probably dispersed by large birds e.g. Currawongs (Buchanan 1989), possibly dispersed by large mammals, kangaroos, possums; soil-stored seedbank, germination triggers unknown (P. Weston pers. comm.).
Fire response: Killed (Krauss 1997).
Interaction with other organisms: Fungi *Camarosporula persooniae, Dichomora* sp. cause leaf spot disease (B. Summerell pers. comm).

Distribution

Status/origin: Native.
Botanical subregions: CC CT.
Distribution Sydney area: Blue Mountains.
Select locations: CC: Bilpin, Kurrajong Heights, Woodford, Springwood. CT: Mt Wilson, Blackheath, Kings Tableland, Little Cedar Gap, Gibraltar Rocks, Jenolan Caves.

Habitat

Habitat: Ridges, hillsides.
Altitude: 400–1100 m **Annual rainfall:** 900–1400 mm
Typical local abundance: Frequent.
Vegetation: Open-forest e.g. with *Eucalyptus piperita, Angophora costata, Syncarpia glomulifera, Eucalyptus notabilis, E. cypellocarpa, E. sieberi, E. blaxlandii.*
Substrate: Sandy soil on sandstones, low nutrients, well-drained.
Exposure:

Conservation

Conservation: Local endemic taxon. Conservation status unknown, reported in Blue Mountains NP.

Persoonia mollis subsp. *nectens* PROTEACEAE

Life history

Growth form: Erect to prostrate shrub, with hairy young branchlets.
Vegetative spread: No.
Longevity:
Primary juvenile period:
Flowers: Yellow, January–April. Long-tongue bee *Leioproctus filamentosa* forages on the flowers (Bernhardt & Walker 1996).
Fruit/seed: Fleshy fruit, with one seed enclosed in a hard, woody stone, shed at maturity, August–October.
Dispersal, establishment & growth: Diaspore: fruit, probably dispersed by large birds e.g. Currawongs (Buchanan 1989), possibly dispersed by large mammals, kangaroos, possums; soil-stored seedbank, germination triggers unknown (P. Weston pers. comm.).
Fire response: Killed (Krauss 1997).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CC CT.
Distribution Sydney area: Woronora Plateau.
Select locations: CC: O'Hares Creek, Loddon Falls, Sublime Point, Mt Keira, Mt Kembla, Thirlmere Lakes, Oakdale. CT: Hill Top.

Habitat

Habitat: Ridgetops.
Altitude: 0–600 m **Annual rainfall:** 900–1800 mm
Typical local abundance: Occasional.
Vegetation: Open-forest e.g. with *Eucalyptus piperita, E. sieberi, E. sparsifolia, E. sclerophylla, Corymbia gummifera, Eucalyptus punctata, E. deanei, E. agglomerata.*
Substrate: Sandy soil over sandstone, low nutrients.
Exposure:

Conservation

Conservation: Local endemic taxon, conservation status unknown.

Persoonia mollis subsp. *revoluta* PROTEACEAE

Life history

Growth form: Prostrate to decumbent shrub, with hairy young branchlets.
Vegetative spread: No.
Longevity:
Primary juvenile period:
Flowers: Yellow, January.
Fruit/seed: Fleshy fruit, with one seed enclosed in a hard, woody stone. Fruit shed at maturity.
Dispersal, establishment & growth: Diaspore: fruit, probably dispersed by large birds e.g. Currawongs (Buchanan 1989), possibly dispersed by large mammals, kangaroos, possums; soil-stored seedbank, germination triggers unknown (P. Weston pers. comm.).
Fire response: Killed (Krauss 1997).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CT.
Distribution Sydney area: Mittagong area.
Select locations: CT: Mittagong, Berrima, Soapy Flat, Bullio.

Habitat

Habitat: Gentle slopes and sandy flats.
Altitude: 600–800 m **Annual rainfall:** 900–1000 mm
Typical local abundance: Occasional.
Vegetation: Open-forest e.g. with *Eucalyptus sclerophylla, E. radiata, E. dives, E. sieberi, E. piperita, E. agglomerata.*
Substrate: Sandy soil over sandstone, low nutrients, well-drained.
Exposure:

Conservation

Conservation: Restricted local endemic taxon, coded 2R on national rare species list (Briggs & Leigh 1996). Adequacy of conservation unknown.

Persoonia myrtilloides subsp. *cunninghamii* PROTEACEAE

Life history

Growth form: Erect to spreading shrub with hairy young branchlets. Occasionally hybridises with *P. acerosa, P. levis, P. recedens* where they grow together.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Yellow, December–May.
Fruit/seed: Fleshy fruit, with one or two seeds enclosed in a hard, woody stone. Fruit shed at maturity, August–September.
Dispersal, establishment & growth: Diaspore: fruit, probably dispersed by large birds e.g. Currawongs (Buchanan 1989), possibly dispersed by large mammals, kangaroos, possums; soil-stored seedbank, germination triggers unknown (P. Weston pers. comm.).
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CT CWS.
Distribution Sydney area: Upper Cudgegong River.
Select locations: CT: Kandos Weir, Coricudgy.

Habitat

Habitat: Ridges with sandstone outcrops.
Altitude: 600–1000 m **Annual rainfall:** 700–800 mm
Typical local abundance: Occasional–frequent.
Vegetation: Woodland e.g. with *Eucalyptus rossii, Angophora floribunda, Callitris, Eucalyptus sclerophylla*; mallee e.g. with *Eucalyptus multicaulis, E. laophila.*
Substrate: Sandy soil, among conglomerate rock outcrops, low nurients, sometimes poorly-drained.
Exposure:

Conservation

Conservation: Southern geographical limit Coricudgy. Conservation adequacy unknown, reported in Wollemi National Park.

Persoonia myrtilloides subsp. *myrtilloides* PROTEACEAE

Life history

Growth form: Erect to spreading shrub to 2 m high, with hairy young branchlets. May hybridise with *P. acerosa, P. levis, P. recedens* where they grow together.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Yellow, October–July, peak December–January. Insect foragers on flowers include: *Exoneura* sp., *Hylaeus* sp., *Homalictus holochorus, Leioproctus (Cladocerapis)* sp., *L. carinatifrons, L. raymenti, L. speculiferus, Odyneurus* sp., *Odyneurus* sp., *Trigona carbonaria* (Bernhardt & Weston 1996).
Fruit/seed: Fleshy fruit, with two seeds enclosed in a hard, woody stone. Fruit shed at maturity, June–December.
Dispersal, establishment & growth: Diaspore: fruit, probably dispersed by large birds e.g. Currawongs (Buchanan 1989), possibly dispersed by large mammals, kangaroos, possums; soil-stored seedbank, germination triggers unknown (P. Weston pers. comm.). Coloniser of disturbed soil such as along margins of pine plantations.
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CT.
Distribution Sydney area: Upper Blue Mountains.
Select locations: CT: Capertee, Wallerawang, Clarence, Newnes Plateau, Mt Wilson, Blackheath, Wentworth Falls.

Habitat

Habitat: Ridges and slopes.
Altitude: 800–1100 m **Annual rainfall:** 900–1400 mm
Typical local abundance: Occasional.
Vegetation: Open-forest e.g. with *Eucalyptus piperita, E. sieberi, E. radiata* with shrubby understorey e.g. with *Banksia serrata, Phyllota squarrosa, Leptospermum trinervium, Lambertia formosa*; occasionally in heath.
Substrate: Sandy loam on sandstone, low nutrients, well-drained.
Exposure:

Conservation

Conservation: Local endemic taxon, partly conserved in Blue Mountains National Park.

Persoonia nutans (*P. nutans* subsp. *A*) PROTEACEAE

Life history

Growth form: Erect to spreading shrub 0.5–1.5 m high, with hairy young branches. Sometimes grows with *P. laurina* and *P. hirsuta* but no hybrids are known (Weston & Johnson 1991).
Vegetative spread: No.
Longevity:
Primary juvenile period:
Flowers: Yellow, mainly December–January. Long-tongue bees *Chalicodoma* sp., *Leioproctus (Cladocerapis)* sp. *L. incanescens* forage on flowers (Bernhardt & Weston 1996).
Fruit/seed: Fleshy fruit, with one or two seeds enclosed in a hard, woody stone, shed at maturity, December–October.
Dispersal, establishment & growth: Diaspore: fruit; probably dispersed by large birds e.g. Currawongs (Buchanan 1989). Possibly dispersed by large mammals, kangaroos, possums; soil-stored seedbank, germination triggers unknown (P. Weston pers. comm.). Disturbance appears to favour seedling establishment (Robertson et al. 1996).
Fire response: Killed (Robertson et al. 1996).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CC.
Distribution Sydney area: Western Sydney.
Select locations: CC: Agnes Banks, Londonderry, St Marys, Kemps Creek, Voyager Point, Macquarie Fields, Villawood.

Habitat

Habitat: Dry woodland.
Altitude: 0–60 m **Annual rainfall:** 800–900 mm
Typical local abundance: Frequent–occasional.
Vegetation: In Castlereagh Scribbly gum Woodland and Agnes Banks Woodland (Benson 1992) e.g. with *Angophora bakeri, Eucalyptus sclerophylla, E. parramattensis, E. fibrosa, Melaleuca decora* and shrubby understorey including e.g. *Melaeuca nodosa, Hakea sericea, Dillwynia tenuifolia, Micromyrtus minutiflora, Banksia spinulosa.*
Substrate: Sandy soils associated with Tertiary alluvium, low nutrients, sometimes poorly drained. More common on well drained deeper sands of Agnes Banks than nearby Londonderry Clay (Robertson et al. 1996).
Exposure: Full sun to light shade.

Conservation

Conservation: Local endemic confined to Cumberland Plain, listed as Endangered (Schedule 1) NSW *Threatened Species Conservation Act 1995* and coded 2ECi on national rare species list (Briggs & Leigh 1996). Most remaining populations are threatened by development for housing and sandmining (Weston & Johnson (1991). Reported in Agnes Banks NR, Windsor Downs NR.

Persoonia oblongata PROTEACEAE

Life history

Growth form: Erect to spreading shrub to 2 m high, with hairy young branches; no lignotuber.
Vegetative spread: No.
Longevity:
Primary juvenile period:
Flowers: Yellow, January–June. Insects foraging on the flowers include *Apis mellifera, Homalictus urbanus, Lasioglossum instabilis, Leioproctus raymenti, Trigona carbonaria* (Bernhardt & Weston 1996).
Fruit/seed: Fleshy fruit, with one or two seeds enclosed in a hard, woody stone, shed at maturity, August–November.
Dispersal, establishment & growth: Diaspore: fruit, probably dispersed by large birds e.g. Currawongs (Buchanan 1989), possibly dispersed by large mammals, kangaroos, possums; soil-stored seedbank, germination triggers unknown (P. Weston pers. comm.).
Fire response: Probably killed.
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CC CT CWS.
Distribution Sydney area: Howes Valley to Blue Mountains.
Select locations: CC: Mellong Range, Howes Swamp, Sackville Reach, Cattai, Winmalee, Blaxland, Glen Davis. CT: Mt Coorongooba.

Habitat

Habitat: Ridges, rocky hillsides.
Altitude: 200–800 m **Annual rainfall:** 900–1000 mm
Typical local abundance: Frequent–occasional.
Vegetation: Eucalypt open-forest to woodland e.g. with *Angophora costata, Eucalyptus sparsifolia, Corymbia gummifera, Eucalyptus notabilis, E. punctata, Angophora bakeri.*
Substrate: Sandy soil on sandstone, low nutrients.
Exposure:

Conservation

Conservation: Conservation status unknown. Reported from Wollemi NP.

Persoonia oxycoccoides PROTEACEAE

Life history

Growth form: Prostrate to spreading shrub to 90 cm high, with hairy young branchlets. Occasionally hybridises with *P. levis*. Apparently intergrades with *P. acuminata* in a limited area between Jenolan Caves and Kanangra Walls; grows with *P. levis* (occasionally hybridises), *P. mollis, P. laurina* (Weston & Johnson 1991).
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Yellow, December–April (Weston & Johnson 1991). Insects foraging on the flowers include *Apis mellifera, Exoneura* sp., *Leioproctus speculiferus* (Bernhardt & Weston 1996).
Fruit/seed: Fleshy green fruit, with one seed enclosed in a hard, woody stone, shed at maturity, September–October.
Dispersal, establishment & growth: Diaspore: fruit, probably dispersed by large birds e.g. Currawongs (Buchanan 1989), possibly dispersed by large mammals, kangaroos, possums; soil-stored seedbank, germination triggers unknown (P. Weston pers. comm.).
Fire response: Resprouts from lignotuber (at Budderoo) (P. Weston pers. comm.).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CT.
Distribution Sydney area: Kanangra, Southern Highlands.
Select locations: CT: Kanangra Walls, Bindook, Mittagong, Bundanoon, Fitzroy Falls, Penrose SF, Wingello.

Habitat

Habitat: Ridgetop.
Altitude: 600–1000 m **Annual rainfall:** 900–1100 mm
Typical local abundance: Occasional.
Vegetation: Montane heath, eucalypt open-forest e.g. with *Eucalyptus sieberi, E. piperita, E. fastigata.*
Substrate: Sandy soils from sandstone, quartzite, low nutrients.
Exposure:

Conservation

Conservation: Local endemic species coded 2RCa on national rare species list (Briggs & Leigh 1996). Adequacy of conservation unknown. Reported in Kanangra-Boyd NP, Buderoo NP, Morton NP.

Persoonia pinifolia PROTEACEAE

Pine-leaved Geebung

Life history

Growth form: Erect shrub or small tree. Rarely hybridizes with *P. isophylla* and *P. linearis.*
Vegetative spread: No.
Longevity: 25–60 years (D. Keith pers. comm.).
Primary juvenile period: More than 5 years (P. Kubiak pers. comm.).

Flowers: Yellow, December–July, peak January (Weston & Johnson 1991). Nectar is sucrose-dominant (Bernhardt & Weston 1996). Native bee *Leioproctus filamentosa* feeds on nectar (P. Bernhardt quoted by Beale1992). Majority of long-tongue native bees foraging on flowers belong to families Anthophoridae, Megachilidae and Apidae; only 7% were *Leioproctus (Cladocerapis)* sp. including *L. incanescens, L. raymenti, L. speculiferus;* other insects foraging on flowers include *Apis mellifera, Chalicodoma* species, *Exoneura* sp., *Trigona carbonaria,* Sphecid wasp (Bernhardt & Weston 1996), *Leioproctus filamentosa, L. hamatus* forage on flowers (Bernhardt & Weston 1996).

Fruit/seed: Fleshy fruit, purplish when ripe, with one seed enclosed in a hard, woody stone. Mean fresh weight of fruit 1270 mg (Westoby et al. 1990). Fruit shed at maturity, November–December.
Dispersal, establishment & growth: Diaspore: fruit, adapted for vertebrate dispersal (Westoby et al. 1990). Probably dispersed by large birds e.g. Currawongs (Buchanan 1989), possibly dispersed by large mammals, kangaroos, possums; soil-stored seedbank (P. Weston pers. comm.). Seed 85% viable, all dormant at release but short-lived in soil (Auld et al. 2000). Fruit eaten by Lewin's Honeyeater *Meliphaga lewinii* (Barker & Vestjens 1990), seed found in dung of Swamp Wallaby (J. Howell pers. comm.). Regurgitated fruit (? from mammals or large birds) observed sometimes along walking tracks; seedlings seem to be more frequently observed along tracks; Antechinus observed apparently gnawing woody-coated seed on ground (September at West Head, L.McD.); germination triggers unknown (P. Weston pers. comm.), germination after woody coat decomposed in leaf litter (in Frenchs Forest garden) (L.McD.).
Fire response: Killed, re-establish from soil-stored seed and/or unburnt plants.
Interaction with other organisms: Fungi *Anthracostloma persooniae, Camarosporula persooniae* cause leaf spot disease (B. Summerell pers. comm.).

Distribution

Status/origin: Native.
Botanical subregions: CC.
Distribution Sydney area: Coast and Lower Blue Mountains.
Select locations: CC: Pearl Beach, Cowan, Berowra, Terrey Hills, Mona Vale, Dee Why, Galston Gorge, Pennant Hills, Turramurra, Lindfield, Leumeah, Wedderburn, Waterfall, Woronora Dam, Bilpin, Springwood.

Habitat

Habitat: Hillsides.
Altitude: 0–500 m **Annual rainfall:** 1000–1200 mm
Typical local abundance: Frequent–occasional.
Vegetation: Open-forest e.g. with *Eucalyptus sieberi, Angophora costata;* woodland e.g. with *Eucalyptus haemastoma, E. piperita, Corymbia gummifera, Allocasuarina littoralis,* understorey e.g. with *Olax stricta, Lasiopetalum ferrugineum, Conospermum longifolium;* heath e.g. with *Hakea sericea, Kunzea ambigua.*
Substrate: Gravelly to sandy soil on sandstone, low nutrients.
Exposure: Full sun to light shade.

Conservation

Conservation: Local endemic species, probably adequately conserved. Reported in Brisbane Water NP, Marramarra NP, Ku-ring-gai Chase NP, Garigal NP, Lane Cove NP, Royal NP.

Persoonia recedens PROTEACEAE

Life history

Growth form: Prostrate to spreading shrub 0.3–1.5 m high, with hairy young branches. Most closely resembles *P. acuminata* (Weston & Johnson 1991).
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Yellow, mainly December–January (Weston and Johnson 1991).
Fruit/seed: Green fleshy fruit, with seed enclosed in a hard woody stone, cotyledons not known (Weston & Johnson 1991). Fruit shed at maturity.
Dispersal, establishment & growth: Diaspore: fruit, probably dispersed by large birds e.g. Currawongs (Buchanan 1989), possibly dispersed by large mammals, kangaroos, possums; soil-stored seedbank, germination triggers unknown (P. Weston pers. comm.).
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CT.
Distribution Sydney area: Newnes Plateau.
Select locations: CT: Newnes SF, Bungleboori, Clarence, Blackheath.

Habitat

Habitat: Plateaus, hillsides.
Altitude: 630–1170 m **Annual rainfall:** 1000–1200 mm
Typical local abundance: Occasional–frequent.
Vegetation: Eucalypt open-forest e.g. with *Eucalyptus radiata, E. dives, E. sieberi, E. gullickii*; grassy, shrubby understorey e.g. with *Phyllota squarrosa, Daviesia latifolia, Lomatia silaifolia, L. myricoides, Polyscias sambucifolia, Banksia spinulosa, Hakea dactyloides, Persoonia chamaepitys, P. myrtilloides.*
Substrate: Sandy siliceous soils, usually derived from Narrrabeen Sandstone (Weston & Johnson 1991), low nutrients.
Exposure: Light shade to full sun.

Conservation

Conservation: Local endemic species, coded 2R on national rare species list (Briggs & Leigh 1996). Confined mainly to Newnes Plateau, with a dubious disjunct record from Abercrombie Caves (Weston & Johnson 1991). Adequacy of conservation unknown.

Persoonia rigida PROTEACEAE

Life history

Growth form: Erect to decumbent shrub, with hairy young branchlets and grey-green leaves.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Yellow, December–January.
Fruit/seed: Fleshy fruit, with one seed enclosed in a hard, woody stone, shed at maturity, September–October.
Dispersal, establishment & growth: Diaspore: fruit, probably dispersed by large birds e.g. Currawongs (Buchanan 1989), possibly dispersed by large mammals, kangaroos, possums; soil-stored seedbank, germination triggers unknown (P. Weston pers. comm.).
Fire response:
Interaction with other organisms: Fungi *Anthracostroma persooniae* and *Camarosporula persooniae* cause leaf spot diseases (B. Summerell pers. comm.).

Distribution

Status/origin: Native.
Botanical subregions: **CC** NT **CT** ST CWS SWS; Vic.
Distribution Sydney area: Tablelands.
Select locations: **CC**: Mt Kembla. **CT**: Growee, Mullions Range, Clandulla SF, Portland, Bathurst, Winburndale, Kedumba.

Habitat

Habitat: Gentle slopes.
Altitude: 0–800 m **Annual rainfall:** 600–1400 mm
Typical local abundance: Rare–occasional.
Vegetation: Open-forest e.g. with *Eucalyptus rossii, E. beyeri, E. tenella, E. punctata, E. macrorhyncha, Persoonia linearis, Dillwynia phylicoides.*
Substrate: Gravelly clay, loamy sand, low nutrients.
Exposure:

Conservation

Conservation: Conservation status unknown. Reported for Winburndale Nature Reserve.

Petrophile canescens PROTEACEAE

Life history

Growth form: Shrub 0.5–1.2 m high, with silvery hairy young shoots; leaves divided.
Vegetative spread: No.
Longevity:
Primary juvenile period:
Flowers: Long, silky, January.
Fruit/seed: Nut 2–5 mm long, in cone, retained on plant as canopy-stored seedbank.
Dispersal, establishment & growth: Diaspore: nut, gravity-dispersed locally.
Fire response: Stems killed, resprouts from base.
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC CC NT CT ST NWS CWS; Qld.
Distribution Sydney area: Mainly Upper Blue Mountains.
Select locations: **CC:** Ingar. **CT:** Olinda, Newnes SF, Clarence, Bouchier Ridge (Oberon), Yerrinbool.

Habitat

Habitat: Deep sands on plateaus.
Altitude: 500–1100 m **Annual rainfall:** 900–1100 mm
Typical local abundance: Frequent.
Vegetation: Woodland e.g. with *Eucalyptus piperita, E. radiata, E. mannifera, E. sclerophylla.*
Substrate: Deep sandy soils from sandstone, low nutrients.
Exposure:

Conservation

Conservation: Conservation status unknown, recorded from Blue Mountains NP.

Petrophile pedunculata PROTEACEAE

Life history

Growth form: Tall glabrous shrub to 2.5 m high.
Vegetative spread: No.
Longevity:
Primary juvenile period:
Flowers: Yellow, mainly November–December.
Fruit/seed: Nut 4 mm long, in cone, retained on plant as canopy-stored seedbank.
Dispersal, establishment & growth: Diaspore: nut, gravity-dispersed locally.
Fire response: Resprouts (at Leura DHB).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CC SC CT.
Distribution Sydney area:
Select locations: **CC:** Grose Vale, Castlereagh, Springwood, Glenbrook, Nortons Basin, Thirlmere, O'Hares Creek, Yerrinbool. **CT:** Lawson, Hill Top, Bundanoon, Wingello, Fitzroy Falls.

Habitat

Habitat: Ridges and flat areas.
Altitude: 0–700 m **Annual rainfall:** 900–1400 mm
Typical local abundance: Occasional–frequent.
Vegetation: Open-forest e.g. with *Syncarpia glomulifera, Corymbia gummifera, Eucalyptus eugenioides, Banksia spinulosa.*
Substrate: Sandy loam over sandstone, low nutrients.
Exposure: Full sun to light shade.

Conservation

Conservation: Conservation status unknown. Reported in Morton NP.

Petrophile pulchella (*P. fucifolia*) PROTEACEAE

Conesticks

Life history

Growth form: Shrub to 3 m high, with divided leaves.
Vegetative spread: No.
Longevity: 25–60 years (D. Keith pers. comm.).
Primary juvenile period: 4 years (Bradstock & O'Connell 1988), 6–9 years (Benson 1985).
Flowers: Yellow, mainly December–January. Possibly pollinated by native bees (P. Kubiak pers. comm.).
Fruit/seed: Nut 4 mm long, weight 9 mg, in a cone, retained on plant as canopy-stored seedbank.
Dispersal, establishment & growth: Diaspore: nut, gravity-dispersed locally, with no special morphology for dispersal (Westoby et al. 1990). Recruitment mainly after fire (D. Keith pers. comm.) from canopy-stored seedbank, released following fire (Bradstock & Auld 1987). Seedling establishment within the first year after fire (Bradstock & Auld 1987).
Fire response: Killed by fire (Bradstock & O'Connell 1988).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC **CC** SC **CT**; Qld.
Distribution Sydney area: Widespread.
Select locations: **CC**: Kulnura, Gosford, Maroota, Yarramundi, Glenbrook, Avalon, Hornsby, Terrey Hills, Pennant Hills, Lindfield, Mosman, Bondi, Kogarah, Loftus, Audley, Stanwell Park. **CT**: Never Never (Rylstone), Newnes SF, Mt Victoria, Wentworth Falls, Kanangra.

Habitat

Habitat: Ridges and slopes.
Altitude: 0–1100 m **Annual rainfall:** 800–1600 mm
Typical local abundance: Frequent–occasional.
Vegetation: Open-forest e.g. with *Eucalyptus piperita, Angophora costata*; woodland e.g. with *Eucalyptus sclerophylla, E. sieberi*; heath e.g. with *Lambertia formosa, Isopogon anemonifolius, Leptospermum trinervium.*
Substrate: Sandy soil on sandstone, sandy alluvium, shale, low nutrients.
Exposure: Full sun to light shade.

Conservation

Conservation: Widespread and probably adequately conserved. Reported from Bouddi NP, Brisbane Water NP, Marramarra NP, Ku-ring-gai Chase NP, Garigal NP, Sydney Harbour NP.

Petrophile sessilis PROTEACEAE

Life history

Growth form: Erect shrub to 3 m high, with hairy young growth and divided leaves.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Yellow, December–January.
Fruit/seed: Nut 3 mm long, in a cone, retained on plant as canopy-stored seedbank.
Dispersal, establishment & growth: Diaspore: nut, gravity-dispersed. No apparent dormancy mechanism, post-fire germination pattern appears to be related to rainfall events rather than season of burning (Whelan & York 1998). Found as small localised populations.
Fire response: Resprouts from base.
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: **CC** SC **CT** ST.
Distribution Sydney area: Woronora Plateau to Budawangs.
Select locations: **CC**: Agnes Banks, Gladesville (1914), Kogarah (1896), Wedderburn, Heathcote, Lucas Heights, Cordeax Dam, Bargo River. **CT**: Bundanoon.

Habitat

Habitat: Ridgetops.
Altitude: 0–600 m **Annual rainfall:** 900–1400 mm
Typical local abundance: Frequent.
Vegetation: Woodland e.g. with *Eucalyptus sclerophylla, Angophora bakeri, Eucalyptus sieberi, E. haemastoma, Corymbia gummifera*; heath e.g. with *Angophora hispida, Kunzea ambigua, Banksia marginata, Brachyloma daphnoides, Lissanthe strigosa.*
Substrate: Sandy soils from sandstone, low nutrient soils.
Exposure: Full sun to light shade.

Conservation

Conservation: Agnes Banks is northern geographical limit. Reported in Lane Cove NP, Royal NP. Conservation status unknown.

Stenocarpus salignus PROTEACEAE

Scrub Beefwood

Life history

Growth form: Multistemmed shrub to 2 m high or tree to 30 m high, with dark brown fissured and finely scaly bark.
Vegetative spread: No.
Longevity:
Primary juvenile period:
Flowers: Yellowish–greenish, mainly October–January, peak November–December. Nectar obtained from flowers by honeybees, native bees, flies and possibly beetles (P. Kubiak pers. comm.).
Fruit/seed: Pod-like fruit 4–6 cm long, with flat, winged seeds 10 mm long, released at maturity. Fruit mature March–June.
Dispersal, establishment & growth: Diaspore: seed, wind-dispersed short distance locally. Seeds germinate readily (Floyd 1989).
Fire response: Resprouted from base after high-intensity fire (at Katandra 1/94) (L.McD.). Secondary juvenile period 3 years after high intensity fire 1/94 (at Lane Cove, P. Kubiak pers. comm.).
Interaction with other organisms: Dark red timber suitable for furniture etc. (Floyd 1989).

Distribution

Status/origin: Native.
Botanical subregions: NC **CC** SC NT **CT** CWS; Qld.
Distribution Sydney area: Widespread.
Select locations: **CC**: Morisset, Yarramalong, Ourimbah, Gosford, Bilpin, Maroota, Glenbrook, Hornsby, Epping, Killara, Oxford Falls, Wedderburn, Douglas Park, Albion Park, Cambewarra. **CT**: Rylstone, Hill Top, Roberson,Wingello.

Habitat

Habitat: Creek banks, gullies.
Altitude: 0–600 m **Annual rainfall:** 800–1400 mm
Typical local abundance: Rare–occasional.
Vegetation: Rainforest e.g. with *Ceratopetalum gummiferum, Doryphora sassafras, Cryptocarya glaucescens, Parsonsia velutina, Acmena smithii*; moist open-forest e.g. with *Eucalyptus piperita, E. deanei, Angophora floribunda, Synoum glandulosum, Elaeocarpus reticulatus, Allocasuarina torulosa*; riparian scrub e.g. with *Lomatia myricoides, Tristania neriifolia, Backhousia myrtifolia, Tristaniopsis laurina, Callicoma serratifolia.*
Substrate: Sandy alluvium, Narrabeen Sandstones, clay soils on basalt, medium to high nutrient soils.
Exposure: Light to medium shade.

Conservation

Conservation: Conservation status unknown. Occasional at Gosford only in a few gullies (R. Payne pers. com.). Creekside habitat is vulnerable to weed invasion e.g. *Ageratina riparia.* Reported in Brisbane Water NP, Marramarra NP, Ku-ring-gai Chase NP, Garigal NP, Lane Cove NP, Royal NP.

Symphionema montanum PROTEACEAE

Life history

Growth form: Multistemmed subshrub 40–80 cm high.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Pale yellow, September–November.
Fruit/seed: Nut, with 1 seed.
Dispersal, establishment & growth: Diaspore: nut, probably shed at maturity (P. Myerscough pers. comm.).
Fire response: Probably killed.
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CC CT.
Distribution Sydney area: Mainly higher parts of Blue Mountains.
Select locations: CC: Kurrajong Heights, Springwood, Woodford. CT: Kekeelbon Mountains, Mt Cameron, Bell, Lithgow, Newnes Junction, Mt Wilson, Mount Tomah, Mt Victoria, Blackheath, Wentworth Falls.

Habitat

Habitat: Ridges, cliff faces.
Altitude: 600–1000 m **Annual rainfall:** 1000–1400 mm
Typical local abundance: Frequent–occasional.
Vegetation: Heath e.g. with *Hakea dactyloides, Lambertia formosa, Caustis flexuosa, Persoonia levis, Acacia suaveolens*; open-forest e.g. with *Eucalyptus sclerophylla, E. piperita, E. sparsifolia, Corymbia gummifera.*
Substrate: Sandy soils on sandstone, low nutrients, sometimes poorly-drained.
Exposure:

Conservation

Conservation: Conservation status unknown. Reported in Blue Mountains NP.

Symphionema paludosum PROTEACEAE

Life history

Growth form: Slender subshrub 30–50 cm high.
Vegetative spread:
Longevity:
Primary juvenile period: Primary juvenile period 2–5 years (D. Keith pers. comm.).
Flowers: Pale yellow, August–November, peak September.
Fruit/seed: Nut, with one seed, probably shed at maturity (P. Myerscough pers. comm.).
Dispersal, establishment & growth: Diaspore: nut. Recruitment mainly after fire (D. Keith pers. comm.). Found in small patches with other subshrubs, herbs and sedges etc. but population may decline as it is out-competed by taller shrubs e.g. *Banksia ericifolia* and *Hakea teretifolia* (L.McD.).
Fire response: Killed by fire (D. Keith pers. comm.).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC CC SC CT ST.
Distribution Sydney area: Coast and Southern Highlands.
Select locations: CC: Somersby, Gosford, Calga, Ku-ring-gai Chase, Frenchs Forest, Willoughby, Manly, Centennial Park, La Perouse, Heathcote, Helensburgh, Appin. CT: Robertson, Carrington Falls, Bundanoon.

Habitat

Habitat: Moist sites.
Altitude: 0–700 m **Annual rainfall:** 1200–1600 mm
Typical local abundance: Frequent–occasional.
Vegetation: Open-forest e.g. with *Eucalyptus sieberi, E. piperita, Corymbia gummifera, Angophora costata, Eucalyptus haemastoma;* wet open-heath e.g. with *Banksia ericifolia, Sprengelia incarnata, Epacris obtusifolia, Lepidosperma flexuosum.*
Substrate: Clay soils on sandstone, with continuous moisture, low nutrients.
Exposure: Full sun to light shade.

Conservation

Conservation: Conservation status unknown. Reported in Ku-ring-gai Chase NP, Heathcote NP. The main populations in Frenchs Forest area not conserved, just outside the boundary of Garigal NP (L.McD.).

Telopea mongaensis PROTEACEAE

Monga or Braidwood Waratah

Life history

Growth form: Multi-stemmed shrub to 6 m high, with rusty hairs on young branchlets; with lignotuber.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Pink to greenish, in loose heads, October–November.
Fruit/seed: Dry woody fruit 4–6 cm long, with winged seeds, released at maturity.
Dispersal, establishment & growth: Diaspore: seed, wind-dispersed short distance.
Fire response: Probably resprouts from lignotubers.
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CT ST.
Distribution Sydney area: Moss Vale.
Select locations: CT: Bundanoon Creek, Meryla.

Habitat

Habitat: Creekbanks.
Altitude: 500–750 m **Annual rainfall:** 1000–1100 mm
Typical local abundance: Frequent–occasional.
Vegetation: Open-forest e.g. with *Eucalyptus sieberi, E. dives, E. piperita, Gleichenia* sp., *Lambertia formosa, Banksia spinulosa, Gahnia* sp.
Substrate: Sandy alluvial soil over sandstone, low nutrients.
Exposure:

Conservation

Conservation: Meryla is northern geographical limit. Rare, possibly vulnerable (P. Weston pers. comm.).

Telopea speciosissima PROTEACEAE

Waratah

Life history

Growth form: Multistemmed, shrub to 3 m high, with lignotuber; leaves usually toothed and with raised veins. There is one record of a hybrid *T. speciosissima* X *mongaensis* collected from the wild (P. Weston pers. comm.).
Vegetative spread: No.
Longevity: Long
Primary juvenile period: 5 years to flowering (Offord 1993).
Flowers: Red, rarely white in a large compact head surrounded by conspicuous pink to red bracts. September–October on coast, November–December on higher mountains. Pollinated by honeyeater birds. Flowers abundantly only after fire (Keith 1996).

Fruit/seed: Dry woody fruit 8–15 cm long, with winged seeds. Mean weight of seed 72 mg (Westoby et al. 1990), released at maturity, March–May, about 6 months after flowering. There may be more than 250 seeds in one flowerhead in a good year, taller individuals have fewer flowers and set less seed (Offord 1993). Fruit set per inflorescence tends to increase with inflorescence height (Pyke 1981), limited by some factor other than amount of pollen received (Pyke 1982).

Dispersal, establishment & growth: Diaspore: winged seed, wind-dispersed locally (Westoby et al. 1990). Seed with no dormancy (Offord 1993). Seedling establishment 2–5 years after fire (Bradstock & Auld 1987).

Fire response: Stems killed, resprouts from lignotuber. Percentage of plants in flower, average number of flowers/inflorescence and average number of fruits/inflorescence appear to peak 2 years after a summer fire and decline thereafter. The average height of the inflorescence above the ground increases following fire (Pyke, 1983). Juveniles take 8 years to become resistant to low intensity fire (Bradstock & Auld 1987). Fire regimes of less than 10 years will result in a decline in population size (Bradstock 1995).

Interaction with other organisms: Host to Cup Moth larvae *Mecytha fasciata* (Common 1990), light brown Apple Moth *Epiphyas postvittana*, Oleander Scale *Aspidiotus nerii*, Waratah bud borer larva *Xylorycta luteotactella*; fungi recorded from the leaves: *Colletotrichum* sp., *Phyllostricta telopeae*, *Periconiella telopeae*, *Meliola laarosa*, *Leptosphaeria telopeae*, *Restalotcopsis* sp. (B. Summerell pers. comm.).

Distribution

Status/origin: Native. Widely cultivated.
Botanical subregions: **CC** SC ST **CT**.
Distribution Sydney area: Widespread.
Select locations: **CC**: Cooranbong, Calga, Maroota, Kurrajong Heights, Springwood, Terrey Hills, Engadine, Oakdale, Albion Park. **CT**: Clarence, Mt Wilson, Blackheath, Katoomba, Kings Tableland, Mittagong, Carrington Falls.

Habitat

Habitat: Plateaus, hillsides.
Altitude: 0–1100 m **Annual rainfall:** 900–1400 mm
Typical local abundance: Frequent–occasional.
Vegetation: Woodland and open-forest e.g. with *Eucalyptus sieberi*, *E. piperita*, *E. sclerophylla*, shrubby understorey e.g. with *Lambertia formosa*, *Leptospermum trinervium*, *Persoonia levis*, *Banksia spinulosa*.
Substrate: Deep, brown or yellow clay soils over sandstone, low to medium nutrients, well-drained. Deep soils give best results in cultivation.
Exposure: Light shade to full sun.

Conservation

Conservation: Reported in Bouddi NP, Brisbane Water NP, Muogamarra Nature Reserve, Ku-ring-gai Chase NP, Garigal NP, Lane Cove NP, Sydney Harbour NP, Blue Mountains NP.

Xylomelum pyriforme PROTEACEAE

Life history

Growth form: Small tree or tall shrub, young shoots and inflorescences covered with rust coloured hairs. Trees to 15 m high reported from Howes Valley.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Rusty red, September–November, peak October. Possibly pollinated by diurnal moths, flies, and honeybees (P. Kubiak pers. comm.).
Fruit/seed: Large, pear-shaped woody capsule 6-9cm long with 2 winged seeds, which may remain on plant for a considerable period, before opening or until burnt.
Dispersal, establishment & growth: Diaspore: winged seed, wind-dispersed locally.
Fire response: Resprouts from trunk and lignotuber and suckers from exposed roots, possibly explaining localised patches of individuals.
Interaction with other organisms: Fungus *Giugnardia* causes leaf spot and *Cephaleutos virescens* causes algal leaf spot (B. Summerell pers. comm.).

Distribution

Status/origin: Native.
Botanical subregions: NC CC CT.
Distribution Sydney area: Widespread, coast and sandstone plateaus.
Select locations: **CC**: Howes Valey, Yengo, Colo Heights, Kulnura, Berowra, Newport, Narrabeen, Pennant Hills, Glenbrook, Rose Bay, Bents Basin, La Perouse, Kurnell, Leumeah, Bundeena, Burragorang, Thirlmere Lakes. **CT**: Kings Tableland, Wentworth Falls, Lawson, Hill Top, Mittagong.

Habitat

Habitat: Ridges and hillsides.
Altitude: 0–1000 m **Annual rainfall:** 900–1400 mm
Typical local abundance: Occasional–frequent.
Vegetation: Open-forest e.g. with *Corymbia eximia, C. gummifera, Eucalyptus haemastoma, E. sieberi, E. capitellata, E. punctata, E. sclerophylla.*
Substrate: Deep soils, often deep sands on sandstone, low nutrients, well-drained.
Exposure:

Conservation

Conservation: Probably adequately conserved. Reported in Bouddi NP, Brisbane Water NP, Marramarra NP, Ku-ring-gai Chase NP, Garigal NP, Lane Cove NP, Sydney Harbour NP, Botany Bay NP, Royal NP.

Batrachium trichophyllum * *(Ranunculus trichophyllus)* RANUNCULACEAE

Life history

Growth form: Submerged aquatic plant, with finely divided leaves repeatedly dividing three ways and set singly along the stem (Romanowski 1998).
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Small whitish, with yellow centres, often purplish on outside (Romanowski 1998), November–April.
Fruit/seed: Head of 15–35 hairy achenes
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms: Foodplant of Black Swan *Cygnus atratus* (Barker & Vestjens 1989,1990).

Distribution

Status/origin: Exotic, native to Europe, Asia , N America.
Botanical subregions: NT **CT** ST CWS; Vic., Tas., S.A.
Distribution Sydney area:
Select locations: **CT**: Sofala, Lowther, Hampton, Edith, Oberon.

Habitat

Habitat: Creeks, rivers.
Altitude: 600–1000 m **Annual rainfall:** 600–900 mm
Typical local abundance: Occasional.
Vegetation: With other aquatic herbs e.g. *Myriophyllum, Potamogeton.*
Substrate: Still or slowly flowing water, and mud on stream bank.
Exposure:

Conservation

Conservation: Naturalised weed. Conservation impact unknown.

Clematis aristata RANUNCULACEAE

Traveller's Joy

Life history

Growth form: Vigorous, woody climber to 6 m high.
Vegetative spread: No (McIntyre et al. 1995), though plants at Penrose have tuberous roots up to 30 cm deep, branching underground, possibly capable of giving rise to separate plants.
Longevity:
Primary juvenile period:
Flowers: White, September–December. Moth larvae *Phrissogonus laticostata* reported on flowers (Common 1990).
Fruit/seed: Head of achenes with feather-like appendages. Achene weight 4–5 mg (Westoby et al. 1990).
Dispersal, establishment & growth: Diaspore: achene, wind-dispersed (Westoby et al. 1990).
Fire response: Resprouted after high intensity fire 1/94, flowering in 38 weeks (at Lane Cove, P. Kubiak pers. comm.).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC **CC** SC NT **CT** ST SWS; Qld, Vic., Tas., W.A.
Distribution Sydney area: Widespread, coast & mountains.
Select locations: **CC**: Ourimbah, Gosford, Hornsby, Silverwater, La Perouse, Stanwell Park, Shellharbour, Springwood. **CT**: Newnes Plateau, Mount Tomah, Robertson, Megalong Valley, Mt Werong, Robertson.

Habitat

Habitat: Creek banks, gullies, lower slopes.
Altitude: 0–1200 m **Annual rainfall:** 1000–1400 mm
Typical local abundance: Frequent–occasional.
Vegetation: Rainforest canopy e.g. with *Ceratopetalum apetalum, Atherosperma moschatum,* and eucalypt forest e.g. with *Eucalyptus pilularis, E. saligna, Syncarpia glomulifera.*
Substrate: Soil variable, shallow sandy soils to gravelly alluvium, clay soils on shale and basalt, Narrabeen Sandstones.
Exposure: Mid shade to full sun.

Conservation

Conservation: Status uncertain. Conserved in Western Sydney (James et al. 1999) (*C. aristata* appears to be relatively rare in Western Sydney compared with *C. glycinoides*). Ecological differences between *C. aristata* and *C. glycinoides* need investigation.

Clematis glycinoides var. *glycinoides* RANUNCULACEAE

Headache Vine

Life history

Growth form: Woody climber to 2.5 m high, often in drier sites than *C. aristata.*
Vegetative spread: No.
Longevity: Possibly 10–20 years.
Primary juvenile period: Possibly 3–5 years.
Flowers: White, July–Dec, peak September.
Fruit/seed: Head of achenes each with featherlike appendage. Achene weight 3–5 mg (Westoby et al. 1990), mature mainly November–December, shed at maturity.
Dispersal, establishment & growth: Diaspore: achene, wind-dispersed (Westoby et al. 1990). Coloniser, though growth rate appears slow.
Fire response: Probably killed.
Interaction with other organisms: Flowers visited by honeybees for pollen (P. Kubiak pers. comm.).

Distribution

Status/origin: Native.
Botanical subregions: NC **CC** SC NT **CT** ST NWS CWS; Qld, Vic.
Distribution Sydney area: Widespread.
Select locations: **CC**: Ocean Beach, Cheltenham, Auburn, Cronulla, Kurrajong, Cobbitty, Razorback, Seven Mile Beach. **CT**: Bell, Limekilns, Glanmire, Wombeyan Caves.

Habitat

Habitat: Gullies, creekbanks.
Altitude: 0–1000 m **Annual rainfall:** 700–1400 mm
Typical local abundance: Occasional–frequent.
Vegetation: Open-forest e.g with *Backhousia myrtifolia, Eucalyptus paniculata, E. viminalis, Backhousia myrtifolia.* Floodplain tall open-forest e.g. with *Eucalyptus amplifolia, Angophora subvelutina* (Scholer 1974); woodland, sometimes heath.
Substrate: Well-drained soils from basalt, limestone, shale, slate, sandstone medium nutrients. Sometimes in disturbed sites. Often in drier sites than *C. aristata.*
Exposure: Light shade–full sun.

Conservation

Conservation: Conservation status unknown.

Clematis microphylla var. *microphylla* — RANUNCULACEAE

Small-leaved Clematis

Life history

Growth form: Woody climber to 3 m high.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Creamy white, usually July–December.
Fruit/seed: Head of achenes with feather-like appendages.
Dispersal, establishment & growth: Diaspore: achene, wind-dispersed.
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NT CT NWS CWS NWP SWP NFWP SFWP; Qld, Vic., Tas., S.A,. W.A.
Distribution Sydney area: Abercrombie Caves.
Select locations: CT: Abercrombie Caves.

Habitat

Habitat:
Altitude: 800 m **Annual rainfall:** 800 mm
Typical local abundance:
Vegetation:
Substrate:
Exposure:

Conservation

Conservation: Abercrombie Caves (1940) is only Sydney area record. Conservation status unknown.

Ranunculus amphitrichus (*R. rivularis* incorrect) — RANUNCULACEAE

Life history

Growth form: Aquatic perennial herb, often with floating leaves and emergent flowers.
Vegetative spread: Stoloniferous.
Longevity:
Primary juvenile period:
Flowers: Pale golden-yellow, October–December.
Fruit/seed: Head of 10–25 achenes, each 1–2 mm long, December.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: SC CT ST; Vic., Tas., N.Z.
Distribution Sydney area: Tablelands.
Select locations: CT: Orange, Hampton, Edith, Oberon.

Habitat

Habitat: Creekbanks and swamps.
Altitude: 900–1200 m **Annual rainfall:** 900–1000 mm
Typical local abundance: Frequent.
Vegetation:
Substrate: Standing water and clayey alluvium, medium nutrients.
Exposure:

Conservation

Conservation: Rarely recorded, conservation status unknown.

Ranunculus collinus RANUNCULACEAE

Life history

Growth form: Perennial herb 10 cm high.
Vegetative spread: Stoloniferous.
Longevity:
Primary juvenile period:
Flowers: Bright golden-yellow, October–December.
Fruit/seed: Head of 10–30 achenes, each 3 mm long, November–December.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: **CT** ST; Vic., Tas.
Distribution Sydney area:
Select locations: **CT**: Mt Coricudgy, Hampton, Little River, Jenolan Caves, Mt Werong, Oberon.

Habitat

Habitat: Creekbanks, moist forest.
Altitude: 1000–1200 m **Annual rainfall:** 800–1200 mm
Typical local abundance: Frequent.
Vegetation: Eucalypt open-forest e.g. with *Eucalyptus viminalis, E. blaxlandii, E. cypellocarpa, E. dalrympleana.*
Substrate: Clay loam on basalt, sandy loam on limestone and granite, medium to high nutrients.
Exposure:

Conservation

Conservation: Conservation status unknown.

Ranunculus flammula * RANUNCULACEAE

Lesser Spearwort

Life history

Growth form: Perennial herb, with leafy flowering stems 8–50 cm long and basal leaves.
Vegetative spread: Rhizomatous or stoloniferous.
Longevity:
Primary juvenile period:
Flowers: Yellow, spring–summer.
Fruit/seed: Head of 20–50 achenes, each 1–2 mm long.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to Europe, N Africa.
Botanical subregions: **CT**.
Distribution Sydney area: Wingecarribee Swamp.
Select locations: **CT**: Wingecarribee Swamp (1987).

Habitat

Habitat: Wet pastures
Altitude: 700 m **Annual rainfall:** 1600 mm
Typical local abundance: Occasional.
Vegetation: Margin of swamp.
Substrate: Peaty sand, low nutrients, poorly-drained.
Exposure:

Conservation

Conservation: Weed, naturalised at Wingecarribee Swamp (1987), potential to spread locally and elsewhere unknown.

Ranunculus inundatus RANUNCULACEAE

Life history

Growth form: Perennial herb, 7–30 cm high, with stolons partly rooted, sometimes free-floating.
Vegetative spread: Stoloniferous.
Longevity:
Primary juvenile period:
Flowers: Yellow, September–December, March.
Fruit/seed: Head of 10–40 achenes, mature October–January.
Dispersal, establishment & growth: Diaspore: fruit.
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC **CC** SC NT **CT** ST SWS SWP; Vic., S.A.
Distribution Sydney area: Widespread.
Select locations: **CC**: Mt Yengo, Wyong, Agnes Banks, Rockdale, St Marys, Macquarie Fields, Corrimal, Bargo, Berry, Wingecarribee. **CT**: Glanmire, Oberon.

Habitat

Habitat: Freshwater swamp, ponds or streams.
Altitude: 0–800 m **Annual rainfall:** 700–1000 mm
Typical local abundance: Frequent.
Vegetation: Sedgeland e.g. with *Eleocharis, Carex, Juncus, Geranium.*
Substrate: Ponds or streams in wet mud or peat, alluvial, often shale-derived, low–medium nutrients. Water table mostly high, moisture supply more or less continuous, fresh.
Exposure: Full sun–light shade.

Conservation

Conservation:

Ranunculus lappaceus RANUNCULACEAE

Common Buttercup

Life history

Growth form: Erect perennial herb 10–60 cm high, with flowering stems 15–50 cm high.
Vegetative spread: No (McIntyre et al. 1995).
Longevity:
Primary juvenile period:
Flowers: Golden-yellow, July to May, peak September–November.
Fruit/seed: Head of 20–50 achenes, each 2–4 mm long, October–June.
Dispersal, establishment & growth: Diaspore with morphology for dispersal by adhesion (McIntyre et al. 1995).
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC **CC** SC NT **CT** ST NWS CWS SWS SWP; Qld, Vic., Tas., S.A.
Distribution Sydney area: Widespread.
Select locations: **CC**: Wyong, Galston, Oatley, Rookwood, Camden, Otford, Corrimal, Albion Park, Springwood. **CT**: Mt Kindarun, Mt Coricudgy, Ben Bullen SF, Bathurst (1892), Mt Canobolas, Jenolan Caves (1899), Abercrombie Caves, Mt Werong, Bowral.

Habitat

Habitat: Damp sites.
Altitude: 0–1200 m **Annual rainfall:** 700–1200 mm
Typical local abundance: Frequent–occasional.
Vegetation: Grassland, forest e.g. with *Eucalyptus deanei, E. viminalis, E. tereticornis, Melaeuca styphelioides.*
Substrate: Clay soils on Wianamatta Shale, alluvium, basalt, granite, medium to high nutrients.
Exposure:

Conservation

Conservation: Vulnerable in Western Sydney (James et al. 1999). Conservation status elsewhere unknown.

Ranunculus muricatus * RANUNCULACEAE

Sharp Buttercup

Life history

Growth form: Herb with flowering stems to 50 cm high.
Vegetative spread: No.
Longevity: Less than 1 year.
Primary juvenile period: Less than 1 year.
Flowers: Yellow, September–October.
Fruit/seed: Head of achenes, each 8 mm long, September–October.
Dispersal, establishment & growth: Vegetative dispersal by bulbs (Whittet 1958).
Fire response:
Interaction with other organisms: Suspected of poisoning stock, but seldom eaten because of its acrid juice (Whittet 1958).

Distribution

Status/origin: Exotic, native to S Europe. Widely naturalised.
Botanical subregions: NC **CC** SC ST **CT** CWS SWS NWP SWP; Qld, Vic., Tas., S.A.
Distribution Sydney area: Mainly Sydney suburban area.
Select locations: **CC**: Pennant Hills, Parramatta, Bexley (1894), Liverpool, Woronora River, Otford, Bomaderry. **CT**: Bathurst.

Habitat

Habitat: Stockyards, drains.
Altitude: 0–900 m **Annual rainfall:** 700–1600 mm
Typical local abundance: Occasional.
Vegetation:
Substrate: Probably on sandy soils. Thrives in wet places (Whittet 1958).
Exposure:

Conservation

Conservation: Widely naturalised, probably a minor weed.

Ranunculus papulentus RANUNCULACEAE

Life history

Growth form: Small or robust perennial herb, with flowering stems 3–30 cm high.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Yellow, spring–autumn.
Fruit/seed: Head of 12–36 achenes, each 4 mm long, November–March.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: **CT** ST SWS; Vic., S.A.
Distribution Sydney area: Tablelands.
Select locations: **CT**: Boyd Plateau, Bathurst, Wingecarribee Swamp, Blayney.

Habitat

Habitat: Wet sites in mud or pools.
Altitude: 700–1200 m **Annual rainfall:** 600–1600 mm
Typical local abundance: Occasional.
Vegetation: Open-heath with sedgeland e.g. with *Empodisma minus, Restio australis, Xyris.*
Substrate: Peaty, low nutrient, permanently moist. Recorded on saline sites in western NSW (Semple 1993).
Exposure:

Conservation

Conservation: Conservation status unknown.

Ranunculus pimpinellifolius RANUNCULACEAE

Life history

Growth form: Perennial herb, with flowering stems 2–25 cm high.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Yellow, November–February.
Fruit/seed: Head of 8–40 achenes, each 2–3 mm long, December–February.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NT **CT** ST; Vic, Tas.
Distribution Sydney area: Oberon–Boyd Plateau.
Select locations: **CT**: Boyd Plateau, Jenolan Caves, Oberon.

Habitat

Habitat: Upland swamps.
Altitude: 1000–1200 m **Annual rainfall:** 800–1000 mm
Typical local abundance: Occasional.
Vegetation: Along narrow shallow streams e.g. with *Gratiola peruviana*; open heath with sedgeland e.g. with *Empodisma minus, Restio australis, Xyris* sp.
Substrate: Peaty, low nutrient, permanently moist.
Exposure:

Conservation

Conservation: Rare, localised occurrence, only one recent record (Kanangra- Boyd NP).

Ranunculus plebeius RANUNCULACEAE

Life history

Growth form: Hairy perennial herb, with flowering stems 8–80 cm high.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Golden-yellow, November–March.
Fruit/seed: Head of achenes, each 2–3 mm long, November-April.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC **CC** SC **CT** ST; Qld, Vic.
Distribution Sydney area: Widespread.
Select locations: **CC**: Avoca, Gordon, Rockdale, Minto, Albion park, Bulli, Kangaroo Valley.
CT: Kowmung Creek, Moss Vale.

Habitat

Habitat: Creekbanks, swamp edges, moist sites.
Altitude: 0–700 m **Annual rainfall:** 700–1400 mm
Typical local abundance: Occasional.
Vegetation: Forest, woodland e.g. with *Eucalyptus dalrympleana*; swamp forest e.g. with *Melaleuca quinquenervia*.
Substrate: Sandy to clayey alluvial soils, basalt, medium to high nutrients.
Exposure:

Conservation

Conservation: Vulnerable in Western Sydney (James et al. 1999), conservation status elsewhere unknown.

Ranunculus pumilio var. *politus* RANUNCULACEAE

Life history

Growth form: Herb, with flowering stems to 40 cm high.
Vegetative spread: No.
Longevity: Less than 1 year.
Primary juvenile period: Less than 1 year.
Flowers: Yellow, late winter to early summer.
Fruit/seed: Head of achenes, each about 2 mm long.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native, introduced to Sydney area.
Botanical subregions: *CC NT CWS SWS NWP SWP; Vic.
Distribution Sydney area:
Select locations: CC: Hawkesbury Agricultural College (1910) (now University of Western Sydney).

Habitat

Habitat: Intermittently moist sites.
Altitude: 0–50 m **Annual rainfall:** 800 mm
Typical local abundance:
Vegetation: Grassland, woodland.
Substrate:
Exposure:

Conservation

Conservation: Native species of inland NSW recorded once (in 1910) in Sydney area. Probably introduced with stock.

Ranunculus pumilio var. *pumilio* RANUNCULACEAE

Life history

Growth form: Herb, with flowering stems to 40 cm high.
Vegetative spread:
Longevity: Less than 1 year.
Primary juvenile period: Less than 1 year.
Flowers: Yellow, late winter to early summer.
Fruit/seed: Head of achenes, each about 2 mm long.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms: Foodplant of Stubble Quail *Coturnix pectoralis* (Barker & Vestjens 1989, 1990).

Distribution

Status/origin: Native.
Botanical subregions: CT ST NWS CWS SWS NWP SWP NFWP SFWP; Qld, Vic., Tas., N.T., S.A., W.A.
Distribution Sydney area: Duckmaloi River.
Select locations: CT: Edith, Oberon.

Habitat

Habitat: Riverbanks, intermittently moist sites.
Altitude: 1000 m **Annual rainfall:** 800 mm
Typical local abundance:
Vegetation: Grassland, woodland.
Substrate: Clay soils.
Exposure:

Conservation

Conservation: Few records for Sydney area, conservation status unknown.

Ranunculus repens * RANUNCULACEAE

Creeping Buttercup

Life history

Growth form: Creeping herb, with leaves clustered along stem; flowering stems 5–60 cm high. Forming dense clumps.
Vegetative spread: Stolons upt o 0.6 m long, rooting at nodes, all nodes capable of regrowth. Single plant can colonise 4 sq metres per year (Chancellor 1980).
Longevity: Perennial.
Primary juvenile period:
Flowers: Golden yellow, September–March, peak October. Possibly pollinated by honeybees and hoverflies (P. Kubiak pers. comm.).
Fruit/seed: Head of achenes, each 3 mm long, mature October. Low seed set (Harden 1990). Seed can survive in soil for several decades (Chancellor 1980).
Dispersal, establishment & growth: Bird-dispersed (Chancellor 1980).
Fire response: Resprouted after high intensity fire 1/94, secondary juvenile period less than 1 year (at Lane Cove, P. Kubiak pers. comm.).
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to Eurasia.
Botanical subregions: NC **CC** SC NT **CT** ST; Vic., Tas., S.A.
Distribution Sydney area:
Select locations: **CC**: Matcham, Oxford Falls, Beecroft, Epping, Ingleburn, Camden, Campbelltown, Austinmer, Wollongong, Gerringong. **CT**: Wingecarribee River.

Habitat

Habitat: Drains, creekbanks, roadsides, moist disturbed sites.
Altitude: 0–700 m **Annual rainfall:** 700–1400 mm
Typical local abundance: Frequent.
Vegetation: With other weed species.
Substrate: Damp ground, clay soils, alluvium, medium to high nutrient soils, poorly-drained.
Exposure:

Conservation

Conservation: Weed of moist, disturbed sites, mainly Sydney and coast but also reported from Southern Highlands. Potential to spread into bushland. For control remove all nodes as they are capable of regrowth (Buchanan 1981).

Ranunculus sceleratus * RANUNCULACEAE

Celery Buttercup

Life history

Growth form: Herb, with flowering stems 20–60 cm high.
Vegetative spread:
Longevity: Usually less than 1 year.
Primary juvenile period: Usually less than 1 year.
Flowers: Pale yellow, September–April.
Fruit/seed: Head of achenes, each less than 1 mm long, September–January.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms: Poisonous to stock (Harden 1991).

Distribution

Status/origin: Exotic, native to Europe.
Botanical subregions: NC CC ST SWS SWP; Vic.
Distribution Sydney area: Mainly western Sydney.
Select locations: CC: Richmond, Riverstone, Waterloo (1912), Doonside, Kogarah, Menangle.

Habitat

Habitat: Creekbanks, ponds.
Altitude: 0–200 m **Annual rainfall:** 700–1000 mm
Typical local abundance: Occasional.
Vegetation:
Substrate: Shallow water, wet mud.
Exposure:

Conservation

Conservation: Conservation impact unknown.

Ranunculus sessiliflorus var. *sessiliflorus* RANUNCULACEAE

Life history

Growth form: Herb, with flowering stems to 35 cm long.
Vegetative spread: No.
Longevity: Less than 1 year.
Primary juvenile period: Less than 1 year.
Flowers: Yellow, September–October.
Fruit/seed: Head of achenes, each 2 mm long, September–October.
Dispersal, establishment & growth: No particular morphology for dispersal (McIntyre et al. 1995).
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC CC NT CT ST NWS CWS SWS NWP SWP NFWP SFWP; Qld, Vic., Tas., S.A., W.A.
Distribution Sydney area: Widespread.
Select locations: CC:Howes Valley, Nortons Basin. CT: Jenolan Caves, Abercrombie Caves, Abercrombie River.

Habitat

Habitat: Intermittently moist sites, riparian, steep slopes.
Altitude: 0–900 m **Annual rainfall:** 800–1000 mm
Typical local abundance:
Vegetation: Riverflat Forest e.g. with *Casurarina cunninghamiana, Acacia binervia, Stellaria flaccida*; woodland e.g. with *Eucalyptus rossii, E. polyanthemos, Cassinia longifolia.*
Substrate: In crevices amongst rocks on limestone, also diatremes, medium nutrients.
Exposure:

Conservation

Conservation: Widespread but localised native annual species with nothing known about its dispersal agents or biology. Vulnerable in Western Sydney (James et al. 1999). Conservation status elsewhere unknown.

Reseda lutea * RESEDACEAE

Cut-leaved Mignonette

Life history

Growth form: Annual or perennial herb 20–80 cm high, with basal rosette.
Vegetative spread: Spread by stolons and root fragments (Heap et al. 1987).
Longevity: Indeterminate (Heap et al. 1987).
Primary juvenile period:
Flowers: Cream, yellow, summer. Pollinated by honeybees (Heap et al. 1987).
Fruit/seed: Oblong capsule 10–15 mm long, with numerous kidney-shaped seeds. Seed production is variable depending on the environment; seed numbers estimated to be 14 000–220 000 on a single plant (Heap et al. 1987).

Dispersal, establishment & growth: Diaspore: seed, shaken from ripe capsule by wind, ants and birds are thought to aid distribution, with long distant spread as a grain contaminant. Cold may stimulate germination; seed passed through gastrointestinal tract of sheep and cattle retain some viability (Heap et al. 1987).
Fire response:
Interaction with other organisms: Grazed by stock but rejected if more palatable feed is available; may taint mutton, beef fat, milk and butter (Heap et al. 1987).

Distribution

Status/origin: Exotic, native to Mediterranean–Asia. Probably introduced to Australia in ballast (Heap et al. 1987).
Botanical subregions: **CC CT** NWS CWS SWS; Qld, Vic., Tas., S.A., W.A.
Distribution Sydney area:
Select locations: **CC**: Richmond (1902). **CT**: Mittagong (1947).

Habitat

Habitat: Pastures and wasteland.
Altitude: 0–700 m **Annual rainfall:** 700–900 mm
Typical local abundance:
Vegetation:
Substrate: Cultivated areas, calcareous soils.
Exposure: Full sun, drought tolerant.

Conservation

Conservation: Weed of agriculture, mainly in SA where it is an exceptionally persistent, competitive and proclaimed noxious species, well adapted to cropping areas (Heap et al. 1987). No evidence of invasion into bushland in Sydney region.

Reseda luteola * RESEDACEAE

Weld

Life history

Growth form: Perennial herb to 1.5 m high.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Pale yellowish, summer.
Fruit/seed: Roundish capsule 5 mm long, with numerous kidney-shaped seeds.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms: Formerly cultivated to produce a yellow dye (Harden 1991). Suspected of producing anti-thyroid activity and death in sheep (Heap et al. 1987).

Distribution

Status/origin: Exotic, native to Europe–Afghanishtan.
Botanical subregions: CC NT **CT** ST NWS CWS SWS NWP SWP; Qld, Vic., Tas., S.A., W.A.
Distribution Sydney area: Widespread.
Select locations: **CC**: Richmond, Ingleburn, Yellow Rock. **CT**: Orange, Kowmung, Rockley (1922), Medlow Bath, Mittagong, Bullio.

Habitat

Habitat: Pastures and wasteland.
Altitude: 0–1000 m **Annual rainfall:** 800–1400 mm
Typical local abundance: Frequent–occasional.
Vegetation:
Substrate: Sandy alluvium, medium nutrients.
Exposure:

Conservation

Conservation: Widespread weed, but no evidence of invasion in bushland.

Alphitonia excelsa RHAMNACEAE

Red Ash

Life history

Growth form: Small to medium-sized tree.
Vegetative spread: No.
Longevity:
Primary juvenile period:
Flowers: Creamy green, fragrant, March–June. Pollination by honeybee *Apis mellifera* and native bees *Trigona carbonaria, ?Pachyprosopis* sp., *Exoneura lawsoni, Leiproctus ?cristatus, Amphylaeus nubilosellus, Heterapoides* spp., *Hyaleus cyanophilus, H. ?jacksoniae, H. rotundiceps, Homalictus brisbanensis, H. flindersi, H. megastigmus, Lasioglossum* spp. (Williams & Adam 1997).
Pollen carried by jewel beetles *Castiarina acuminata, C. neglecta, C. producta*; dung beetles *Eupoecila australasiae, Glycyphana brunnipes, Polystigma punctatum*; blowfly *Paramenia* sp.; hover fly *Dideopsis* sp.; Ichneumon wasp *Echthromorpha intricatoria*; hairy flower wasps *Camsomeris ?tasmaniensis, Scolia verticollis*; sand wasps *Bembicinus* sp., *Bembix promontorii, Bembix* sp., *Sphex ephippium, S. fumipennis, Tachysphex* sp.; flower wasps *Anthobosca ?signata, Diamma bicolor, Thagisgaster* sp., *Zaspilothynnus* sp.; paper wasps *Polistes humilis, P. tepidus* (Williams & Adam 1998).

Fruit/seed: Black, drupaceous fruit, 5–10 mm diam. containing 2 glossy dark brown flattened oval seeds about 4 mm long, covered by a thin dark orange-red shiny skin; 9500 fruits and 21 500 seeds per kilogram (Floyd 1989). Fruit mature August–May but remains on tree for some months.
Dispersal, establishment & growth: Diaspore: fruit. Germination very slow, 8 months for 70% germination; fracturing of hard coat reduces dormancy; seed stored at room temperature 15–20 years was 30–70% viable (Floyd 1989). Coloniser species, although seen on edges can also occur as mature specimens in gully rainforest (R. Payne pers. comm).
Fire response:
Interaction with other organisms: Food plant of butterfly larvae *Danis hymetus taygetus* (Common & Waterhouse 1981), *Hypochrysops delicia, H. ignita* (Braby 2000). Fruit eaten by Grey-headed Flying Fox *Pteropus poliocephalus* (Eby 1995), Brown Cuckoo-dove, Green Catbird, Lewin's Honeyeater, Olive-backed Oriole, Pied Currawong, Silvereye, Regent Bowerbird (Floyd 1989), Brown Pigeons (R. Payne pers. comm.).

Distribution

Status/origin: Native.
Botanical subregions: NC CC SC NWS CWS NWP; Qld, N.T., W.A.
Distribution Sydney area: Hawkesbury area, lower Blue Mountains and Illawarra.
Select locations: **CC**: Ourimbah, North Avoca, Wisemans Ferry, Liverpool, Grose Vale, Warragamba, Razorback, Bass Point, Albion Park, Minnamurra Falls. **CT**: Mt Victoria, Macquarie Pass.

Habitat

Habitat: Sheltered gullies, steep slopes, or along creeks.
Altitude: 0–1000 m **Annual rainfall:** 700–1400 mm
Typical local abundance: Occasional.
Vegetation: Warmer rainforest e.g. with *Doryphora sassafras, Sloanea australis*; drier rainforest e.g. with *Brachychiton populneus, Clerodendrum tomentosa , Hibiscus heterophyllus*; scrub and open forest e.g. with *Eucalyptus robusta, Callicoma serratifolia, Duboisia myoporoides, Glochidion ferdinandi.*
Substrate: Soils on alluvium, shale, medium to high nutrients, well-drained.
Exposure: Sheltered, mid shade. Able to withstand seaside conditions at Wollongong (Fuller 1980).

Conservation

Conservation: Conservation status unknown. There appear to be no early records for the North Shore area — plants there now may be garden escapes. Reported in Wambina NR, Brisbane Water NP, Marramarra NP, Muogamarra NP, Ku-ring-gai Chase NP, Royal NP.

Cryptandra amara var. *amara* RHAMNACEAE

Life history

Growth form: Small heath-like shrub to 60 cm high.
Vegetative spread: No.
Longevity:
Primary juvenile period:
Flowers: White to pinkish, clustered at the ends of branches, April–October, peak August. Possibly pollinated by native bees, flies and butterflies (P. Kubiak pers. comm.).
Fruit/seed: Capsule, enclosed in a persistent flora tube. Seed weight 0.6 mg (Westoby et al. 1990).
Dispersal, establishment & growth: Diaspore: seed, with food body ant-adapted for dispersal (Westoby et al. 1990).
Fire response: Stems killed, resprouts from base.
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC **CC** SC NT **CT** ST NWS CWS SWS NWP SWP; Qld, Vic., Tas., S.A.
Distribution Sydney area: Widespread on coast and ranges.
Select locations: **CC**: Wilberforce, Kenthurst, Botany Bay, Canterbury (1887), Menai, Audley.
CT: Winburndale NR, Mittagong, Penrose SF, Barbers Creek.

Habitat

Habitat: Ridges and plateaus.
Altitude: 0–800 m **Annual rainfall:** 700–1200 mm
Typical local abundance: Rare–frequent.
Vegetation: Woodland e.g. with *Corymbia gummifera, Eucalyptus punctata, E. racemosa, E. sieberi, Banksia spinulosa, B. oblongifolia;* heath e.g. with *Grevillea speciosa, Banksia marginata, B. ericifolia, Angophora hispida, Kunzea ambigua.*
Substrate: Sandy soil over sandstone, low nutrients.
Exposure: Full sun to light shade.

Conservation

Conservation: Reported in Marramarra NP, Garigal NP, Sydney Harbour NP, Royal NP. Probably adequately conserved.

Cryptandra amara var. *floribunda* RHAMNACEAE

Life history

Growth form: Small heath-like shrub to 60 cm high.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: White, clustered at the ends of branches, September–October.
Fruit/seed: Capsule.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NT **CT** ST NWS CWS NWP SWP; Qld, Vic.
Distribution Sydney area: Widespread on Tablelands.
Select locations: **CT**: Kandos Weir, Inglewood, Ben Bullen, Winburndale NR.

Habitat

Habitat: Sandstone outcrops, ridges.
Altitude: 600–900 m **Annual rainfall:** 600–800 mm
Typical local abundance: Occasional.
Vegetation: Eucalypt open-forest and heath e.g. with *Leptospermum parvifolium.*
Substrate: Sandy soil on sandstone, low nutrients.
Exposure:

Conservation

Conservation: Conservation status unknown.

Cryptandra amara var. *longiflora* RHAMNACEAE

Life history

Growth form: Small heath-like shrub to 60 cm high.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: White, June–November, peak September.
Fruit/seed: Capsule.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC **CC** NT **CT** ST NWS CWS SWS SWP; Qld, Vic., Tas.
Distribution Sydney area: Mostly Tablelands.
Select locations: **CC**: Como (1887), Glenfield (1964). **CT**: Currant Mountain Gap, Orange, Kowmung River, Kings Tableland

Habitat

Habitat: Rocky hillside, roadside.
Altitude: 0–1000 m **Annual rainfall:** 700–1200 mm
Typical local abundance: Frequent–occasional.
Vegetation:
Substrate: Clay soils on slate, shale, Devonian quartzite.
Exposure:

Conservation

Conservation: Possibly now extinct in Western Sydney. Conservation status unknown.

Cryptandra buxifolia RHAMNACEAE

Life history

Growth form: Spreading heath-like shrub 15–60 cm high.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Whitish, hairy, surrounded by brown bracts, mainly winter–spring.
Fruit/seed: Capsule, enclosed in a persistent flora tube.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC **CC** **CT** ST CWS.
Distribution Sydney area: Upper Hunter Valley, Howes Valley.
Select locations: **CC**: Yengo NP.

Habitat

Habitat: Forest.
Altitude: 300–400 m **Annual rainfall:** 1000 mm
Typical local abundance: Occasional.
Vegetation: Open-forest
Substrate: Sandy loam on sandstone.
Exposure:

Conservation

Conservation: Reported in Yengo NP. Conservation status unkown.

Cryptandra ericoides RHAMNACEAE

Life history

Growth form: Heath-like shrub to 60 cm high, with leaves often appearing clustered.
Vegetative spread: No.
Longevity: 25–60 years (D. Keith pers. comm.).
Primary juvenile period: 3 years (Benson 1985, Keith 1996).
Flowers: Whitish to pinkish, with brown bracts, February–May.
Fruit/seed: Capsule, enclosed in a persistent flora tube. Seed 0.4 mg (Westoby et al. 1990).
Dispersal, establishment & growth: Diaspore: seed, with a food body, dispersed by ants (Westoby et al. 1990, Rice & Westoby 1981). Recruitment mainly after fire (D. Keith pers. comm.).
Fire response: Killed by fire (Keith 1996).
Interaction with other organisms: Probably eaten by rabbits (P. Kubiak pers. comm.).

Distribution

Status/origin: Native.
Botanical subregions: **CC** SC **CT**.
Distribution Sydney area: Mainly coastal, south from Gosford.
Select locations: **CC**: Brisbane Water NP, Frenchs Forest, Rose Bay, La Perouse, Kurnell, Heathcote, Leumeah. **CT**: Mount Banks, Kings Tableland, Woodford, Robertson.

Habitat

Habitat: Ridges.
Altitude: 0–1000 m **Annual rainfall:** 800–1400 mm
Typical local abundance: Rare–frequent.
Vegetation: Heath e.g. with *Angophora hispida, Allocasuarina distyla, Banksia ericifolia.*
Substrate: Damp sandy soil on sandstone, low nutrients.
Exposure: Light shade.

Conservation

Conservation: Gosford is the northern geographical limit. Reported from Brisbane Water, Ku-ring-gai Chase, Garigal, Royal and Blue Mountains National Parks. Conservation status unknown.

Cryptandra propinqua RHAMNACEAE

Life history

Growth form: Rigid much-branched heath-like shrub to 1 m high, with star-like hairs on branches.
Vegetative spread: No.
Longevity:
Primary juvenile period:
Flowers: In a spike-like arrangement, April–September, peak April–May.
Fruit/seed: Capsule, enclosed in a persistent flora tube.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC **CC** SC NT **CT** ST NWS NWP SWP SFWP; Qld, Vic., S.A., W.A.
Distribution Sydney area:
Select locations: **CC**: Belmont, Maroota, Brooklyn, Paramatta River, Hurstville, Blakehurst, Revesby. **CT**: Bathurst.

Habitat

Habitat: Gullies.
Altitude: 0–200 m **Annual rainfall:** 600–1200 mm
Typical local abundance:
Vegetation:
Substrate: Sandy soil on sandstone, low nutrients.
Exposure:

Conservation

Conservation: Conservation status unknown, though many Sydney localities have now been destroyed by urban expansion.

Cryptandra species *A* RHAMNACEAE

Life history

Growth form: Heath-like shrub to 120 cm high, sometimes with numerous stems from a woody rootstock.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: With brown bracts, winter.
Fruit/seed: Capsule, enclosed in a persistent flora tube.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CC.
Distribution Sydney area: Lake Burragorang district.
Select locations: CC: Lake Burragorang.

Habitat

Habitat:
Altitude: 0–500 m **Annual rainfall:** 800 mm
Typical local abundance:
Vegetation: Open-forest.
Substrate: Probably on sandstone.
Exposure:

Conservation

Conservation: Rare local endemic, confined to the Lake Burragorang district, very few collections. Conservation status unknown.

Cryptandra spinescens RHAMNACEAE

Life history

Growth form: Straggling, much-branched heath-like shrub to 1 m high.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: White, May–November, peak August–October.
Fruit/seed: Capsule, enclosed in a persistent flora tube, September–October.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC CC CT CWS.
Distribution Sydney area:
Select locations: CC: Howes Valley, Mogo Creek, Doonside, St Marys, Cabramatta, Liverpool, Campbelltown. CT: Mount Canobolas, Barbers Creek.

Habitat

Habitat: Rocky sites.
Altitude: 0–1400 m **Annual rainfall:** 700–1000 mm
Typical local abundance: Occasional.
Vegetation: Woodland e.g. with *Eucalyptus fibrosa, Melaleuca decora, Eucalyptus eugenioides, Angophora floribunda, Melaleuca nodosa, Themeda australis.*
Substrate: Clay soil on Tertiary alluvium, Wianamatta Shale, sandy loam on sandstone, low nutrients, well-drained.
Exposure:

Conservation

Conservation: Vulnerable in Western Sydney (James et al. 1999). Conservation status elsewhere unknown.

Discaria pubescens RHAMNACEAE

Australian Anchor Plant

Life history

Growth form: Much-branched rigid shrub to 2.5 m high, with prominent spines and leaves often falling early.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Clustered in groups at base of spines, October–November.
Fruit/seed: Capsule 4–5 mm in diam., November–December.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NT CT ST NWS; Qld, Vic., Tas.
Distribution Sydney area: Tablelands.
Select locations: CT: Ophir, Lett River, Jenolan Caves, Abercrombie Caves, Tuena, Wombeyan Caves.

Habitat

Habitat: Rocky hillsides.
Altitude: 600–800 m **Annual rainfall:** 600–800 mm
Typical local abundance: Occasional–frequent.
Vegetation: Woodland e.g. with *Eucalyptus viminalis.*
Substrate: Sandy to clay soils on granite, limestone conglomerate and sediments, medium nutrients.
Exposure:

Conservation

Conservation: Widespread but rare, coded 3RCa on national rare species list (Briggs & Leigh 1996).

Emmenosperma alphitonioides RHAMNACEAE

Life history

Growth form: Medium-sized tree, with leaves mostly opposite.
Vegetative spread: No.
Longevity:
Primary juvenile period:
Flowers: White, October.
Fruit/seed: Fleshy, orange–yellow fruit, 4–8 mm diam., with 2–3 seeds, mature March–July; 30 000 seeds per kilogram (Floyd 1989).
Dispersal, establishment & growth: Diaspore: seed. Germination difficult unless lightly filed (Floyd 1989).
Fire response:
Interaction with other organisms: Timber pale yellow to golden brown, hard and straight-grained, difficult to work; suitable for tool handles and boat building and is good bending timber (Floyd 1989).

Distribution

Status/origin: Native.
Botanical subregions: NC CC; Qld.
Distribution Sydney area: Coastal.
Select locations: CC: Yarramalong, Wyong, Ourimbah, Gosford, Kurrajong Heights, Royal NP, Whispering Gallery, Albion Park, Minnamurra Falls, Nowra.

Habitat

Habitat: Along creeks.
Altitude: 0–500 m **Annual rainfall:** 1200–1600 mm
Typical local abundance: Rare.
Vegetation: Rainforest with *Doryphora sassafras, Ceratopetalum apetalum, Cryptocarya glaucescens*; drier rainforest e.g. with *Ficus coronata, Alectryon subcinereus, Backhousia myrtifolia.*
Substrate: Alluvial soil, scree slopes, medium nutrients.
Exposure: Sheltered.

Conservation

Conservation: Uncommon in Gosford area, known only from Ourimbah (R. Payne pers. comm.), conservation status elsewhere unknown. Meroo, Nowra is southern limit.

Pomaderris adnata RHAMNACEAE

Life history

Growth form: Spreading shrub to 2 m high, with hairy young stems (Walsh & Coates 1997).
Vegetative spread: No.
Longevity: 10–25 years (N. Walsh pers. comm.).
Primary juvenile period:
Flowers: Cream, usually with petals, September. Buds present for many months before flowers open (Harden 2000a).
Fruit/seed: Egg-shaped, blackish hairy capsule 3 mm long, separating into 3 segments, with seed 1.8 mm long, mature November–December.
Dispersal, establishment & growth:
Fire response: Probably killed (N. Walsh pers. comm.).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CC.
Distribution Sydney area: Bulli.
Select locations: CC: Sublime Point (Bulli).

Habitat

Habitat: Plateau behind escarpment.
Altitude: 300 m **Annual rainfall:** 1400 mm
Typical local abundance: Rare.
Vegetation: Heathy woodland e.g. with *Eucalyptus sieberi, Corymbia gummifera, Acacia longifolia, Aotus ericoides, Lambertia formosa.*
Substrate: Sandy loam over sandstone, low nutrients.
Exposure:

Conservation

Conservation: Very restricted local endemic, known from a population of less than 10 plants on the Illawarra escarpment. Listed as Endangered (Schedule 1) NSW *Threatened Species Conservation Act 1995.* Coded 1V in terms of Briggs and Leigh (1988) (Walsh & Coates 1997). Inadequately conserved.

Pomaderris andromedifolia subsp. *andromedifolia* RHAMNACEAE

Life history

Growth form: Shrub 1–2 m high with young stems rusty-hairy.
Vegetative spread: No.
Longevity: 10–25 years (N. Walsh pers. comm.).
Primary juvenile period:
Flowers: Cream to yellow, with petals, September–October. Buds present for many months before flowers open (Harden 2000a).
Fruit/seed: Capsule 4 mm long with long whitish hairs, separating into 3 segments; seed 2 mm long.
Dispersal, establishment & growth:
Fire response: Probably killed (N. Walsh pers. comm.).
Interaction with other organisms: Food plant of butterfly larvae *Hypochrysops byzos byzos* (Common & Waterhouse 1981).

Distribution

Status/origin: Native.
Botanical subregions: NC **CC** SC NT **CT** ST CWS NWP; Qld, Vic.
Distribution Sydney area: Woronora Plateau, Blue Mountains.
Select locations: **CC**: Waterfall, O'Hares Creek, Appin, Kentlyn, Woronora River, Buxton.
CT: Nullo Mountain, Clarence, Running Stream, Mt Banks, Blackheath, Penrose.

Habitat

Habitat: Ridges and escarpments.
Altitude: 0–1000 m **Annual rainfall:** 900–1400 mm
Typical local abundance: Occasional.
Vegetation: Open-forest e.g. with *Eucalyptus piperita, Angophora costata, Eucalyptus sieberi, E. agglomerata.*
Substrate: Moist sandy loam on sandstone, low nutrients.
Exposure:

Conservation

Conservation: Conservation status unknown.

Pomaderris andromedifolia subsp. *confusa* (*P.* sp. *A*) RHAMNACEAE

Life history

Growth form: Shrub 1–2 m high with greyish- or rusty-hairy young stems .
Vegetative spread: No.
Longevity: 10–25 years (N. Walsh pers. comm.).
Primary juvenile period:
Flowers: Cream, with petals, September–October. Buds present for many months before flowers open (Harden 2000a).
Fruit/seed: Capsule 4 mm long with long whitish hairs, separating into 3 segments; seed 2 mm long, mature December.
Dispersal, establishment & growth:
Fire response: Probably killed (N. Walsh pers. comm.).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: SC **CC CT** ST.
Distribution Sydney area:
Select locations: **CC**: Woolwash (1968). **CT**: Ophir Creek (1899), Coxs River (1904).

Habitat

Habitat: Riparian scrub, ridge top shrubland, woodland and forest (Walsh & Coates 1997).
Altitude: 0–800 m **Annual rainfall:** 800–900 mm
Typical local abundance:
Vegetation: Open-forest; woodland; shrubland; riparian scrub
Substrate: Shallow or skeletal soils.
Exposure:

Conservation

Conservation: Uncommon in Sydney area and at northern limit of distribution. Conservation status unknown.

Pomaderris angustifolia RHAMNACEAE

Life history

Growth form: Shrub to 3 m high, with a covering of dense intertwined stellate hairs; leaves narrow-oblong about 1.5 cm long.
Vegetative spread: No.
Longevity: 10–25 years (N. Walsh pers. comm.).
Primary juvenile period:
Flowers: Creamish, petals absent. Buds present for many months before flowers open (Harden 2000a).
Fruit/seed: Capsule, separating into 3 segments.
Dispersal, establishment & growth:
Fire response: Probably killed (N. Walsh pers. comm.).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NT **CT** ST NWS CWS SWS; Vic.
Distribution Sydney area: Tablelands.
Select locations: **CT**: Ophir, Winburndale NR, Tarana, Glenowlan Mountain, Coxs River, Abercrombie River.

Habitat

Habitat: Near creeks.
Altitude: 400–800 m **Annual rainfall:** 600–900 mm
Typical local abundance: Frequent.
Vegetation: Open-forest and woodland e.g. with *Angophora floribunda, Eucalyptus punctata, Acacia parvipinnula, Cassinia longifolia.*
Substrate: Sandy or clay soils, low nutrients.
Exposure:

Conservation

Conservation: Conservation status unknown. Reported Winburndale Nature Reserve.

Pomaderris aspera (*P. apetala* misapplied) RHAMNACEAE

Hazel Pomaderris

Life history

Growth form: Shrub to 10 m high, with young stems rusty-hairy.
Vegetative spread: No.
Longevity: 10–25 years (N. Walsh pers. comm.).
Primary juvenile period:
Flowers: Greenish yellow, petals absent, October–November. Buds present for many months before flowers open (Harden 2000a).
Fruit/seed: Capsule, separating into 3 segments, November–January.
Dispersal, establishment & growth: Ant-dispersed (Rice & Westoby 1981). Soil-stored seed germinates after forest fires (Langkamp 1987). Seedbank in soil 0–5 cm deep in 54-year old forest but absent from younger forest up to 18 years (Wang 1997).
Fire response: Probably killed (N. Walsh pers. comm.).
Interaction with other organisms: Foodplant of moth caterpillar *Casbia eccentris* (Coupar & Coupar 1992) and butterfly larvae *Hypochrysops byzos* (Braby 2000).

Distribution

Status/origin: Native.
Botanical subregions: NC **CC** SC NT **CT** ST CWS SWS; Vic., Tas.
Distribution Sydney area: Widespread, mainly Illawarra and Blue Mountains.
Select locations: **CC**: Nortons Basin, Razorback, Dapto, Albion Park, Shellharbour.
CT: Mt Coricudgy, Mount Wilson, Wentworth Falls, Mount Werong, Wombeyan Caves, Hill Top, Berrima, Bundanoon.

Habitat

Habitat: Moist forest, along streams, gullies.
Altitude: 0–1100 m **Annual rainfall:** 900–1400 mm
Typical local abundance: Frequent–occasional.
Vegetation: Moist forest e.g. with *Eucalyptus quadangulata*; rainforest e.g. with *Acacia binervata*.
Substrate: Gravelly alluvium, soils on sandstone, granite, shale, basalt, low to medium nutrients.
Exposure:

Conservation

Conservation: Conservation status unknown.

Pomaderris betulina subsp. *betulina* RHAMNACEAE

Life history

Growth form: Shrub 1–4 m high, with a covering of rusty dense intertwined stellate hairs on young stems.
Vegetative spread: No.
Longevity: 10–25 years (N. Walsh pers. comm.).
Primary juvenile period:
Flowers: Yellowish, petals absent. Buds present for many months before flowers open (Harden 2000a).
Fruit/seed: Capsule 4 mm long, separating into 3 segments, with seed 2 mm long.
Dispersal, establishment & growth:
Fire response: Probably killed (N. Walsh pers. comm.).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC SC NT **CT** ST; Vic.
Distribution Sydney area:
Select locations: **CT**: Abercrombie River.

Habitat

Habitat: Damp places.
Altitude: 500 m **Annual rainfall:** 900–1000 mm
Typical local abundance: Frequent.
Vegetation: Riparian vegetation e.g. with *Casuarina cunninghamiana, Acacia amoena, A. dealbata.*
Substrate: Sandy alluvial soil.
Exposure:

Conservation

Conservation: Conservation status unknown.

Pomaderris brunnea RHAMNACEAE

Life history

Growth form: Shrub to 2–3 m high, with characteristic hairs on leaf vein endings.
Vegetative spread: No.
Longevity: 10–25 years (N. Walsh pers. comm.).
Primary juvenile period:
Flowers: Yellowish, without petals, August–October. Buds present for many months before flowers open (Harden 2000a).
Fruit/seed: Capsule with long rusty hairs, separating into 3 segments, November–January.
Dispersal, establishment & growth: Diaspore: seed.
Fire response: Probably killed (N. Walsh pers. comm.).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CC.
Distribution Sydney area: Mainly Colo River, Camden–Picton area.
Select locations: CC: Boorai Creek, Elderslie, Camden Park, Wirrimbirra Creek.

Habitat

Habitat: Creek and riverbanks.
Altitude: 0–300 m **Annual rainfall:** 800–1000 mm
Typical local abundance: Frequent–occasional.
Vegetation: Riverine forest e.g. with *Eucalyptus elata, E. tereticornis, E. amplifolia, E. baueriana, E. elata, Bursaria spinosa, Stipa verticillata, Acacia floribunda.*
Substrate: Sandy loam from riverine alluvium or sandstone, low nutrient, well-drained.
Exposure:

Conservation

Conservation: Local endemic listed as Vulnerable (Schedule 2) NSW *Threatened Species Conservation Act 1995.* Coded 2VC- on national rare species list (Briggs & Leigh 1996). Poorly-known and not adequately conserved. Vulnerable in Western Sydney (James et al. 1999). Confined to Colo River and upper Nepean River.

Pomaderris cotoneaster RHAMNACEAE

Life history

Growth form: Shrub 1–2 m high, with covering of short whitish dense interwoven stellate hairs.
Vegetative spread: No.
Longevity: 10–25 years (N. Walsh pers. comm.).
Primary juvenile period:
Flowers: Creamish, petals absent. Buds present for many months before flowers open (Harden 2000a).
Fruit/seed: Capsule not seen; *Pomaderris* capsules separate into 3 segments (Harden 2000a).
Dispersal, establishment & growth:
Fire response: Probably killed (N. Walsh pers. comm.).
Interaction with other organisms: Foodplant of butterfly larvae *Hypochrysops byzos* (Braby 2000).

Distribution

Status/origin: Native.
Botanical subregions: SC CT ST; Vic.
Distribution Sydney area: Southern Highlands.
Select locations: CT: Tallong, Wingello.

Habitat

Habitat: Open-forest.
Altitude: 600–700 m **Annual rainfall:** 1000–1100 mm
Typical local abundance: Rare.
Vegetation: Open-forest.
Substrate: Sandy soils on Shoalhaven sandstone, low nutrients.
Exposure:

Conservation

Conservation: Listed as Endangered (Schedule 1) NSW *Threatened Species Conservation Act 1995.* Wingello is northern geographical limit.

Pomaderris discolor RHAMNACEAE

Life history

Growth form: Shrub 1–3 m high; stems with a whitish covering of short stellate hairs and scattered longer simple hairs.
Vegetative spread: No.
Longevity: 10–25 years (N. Walsh pers. comm.).
Primary juvenile period: About 3 years after high intensity fire 1/94 (at Lane Cove, P. Kubiak pers. comm.).
Flowers: Pale yellowish, petals absent or falling early, September–October. Buds present for many months before flowers open (Harden 2000a). Peak flowering period less than 5 years after high intensity fire 1/94 (at Lane Cove); possibly pollinated by native bees and honey-bees P. Kubiak pers. comm.).
Fruit/seed: Hairy capsule, separating into 3 segments, November.
Dispersal, establishment & growth:
Fire response: Killed after high intensity fire 1/94 (at Lane Cove, P. Kubiak pers. comm.).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC **CC** SC **CT** SWS; Qld, Vic.
Distribution Sydney area: Mainly coast.
Select locations: **CC**: Hornsby, Gordon, Liverpool, Waterfall, Kentlyn, Thirlmere, Kangaroo Valley. **CT**: Bowral, Yerranderie.

Habitat

Habitat: Gullies and along creeks.
Altitude: 0–600 m **Annual rainfall:** 800–1400 mm
Typical local abundance:
Vegetation: Open-forest
Substrate: Sandy soils on sandstone, alluvium, low nutrients.
Exposure:

Conservation

Conservation: Conservation status unknown, reported from Marramarra NP, Lane Cove NP, Royal NP.

Pomaderris elliptica var. *elliptica* (*P. multiflora*) RHAMNACEAE

Life history

Growth form: Shrub 1–4 m high, with short close covering of stellate hairs; leaves elliptic to lanceolate, usually 5–7 cm long.
Vegetative spread: No.
Longevity: 10–25 years (N. Walsh pers. comm.).
Primary juvenile period:
Flowers: Yellow, with petals, September–October. Buds present for many months before flowers open (Harden 2000a). Visited by native bees for pollen (P. Kubiak pers. comm.).
Fruit/seed: Capsule, separating into 3 segments, October–December.
Dispersal, establishment & growth:
Fire response: Probably killed (N. Walsh pers. comm.).
Interaction with other organisms: Foodplant of butterfly larvae *Hypochrysops byzos*, *H. ignita* (Common & Waterhouse 1972).

Distribution

Status/origin: Native.
Botanical subregions: NC **CC** SC **CT** ST CWS; Vic., Tas.
Distribution Sydney area:
Select locations: **CC**: Narrabeen, Neutral Bay, O'Hares Creek, Douglas Park, Bulli, Macquarie Pass, Woodford, Springwood. **CT**: Wentworth Falls, Hill Top, Belmore Falls, Bundanoon, Wingello.

Habitat

Habitat: Creek banks, gullies.
Altitude: 0–1000 m **Annual rainfall:** 800–1400 mm
Typical local abundance: Frequent–occasional.
Vegetation: Open-forest e.g. with *Angophora costata, Eucalyptus piperita, E. sieberi, E. mannifera, E. deanei.*
Substrate: Sandy alluvium, medium nutrients.
Exposure:

Conservation

Conservation: Conservation status unknown. Reported in Brisbane Water NP, Garigal NP, Sydney Harbour NP.

Pomaderris eriocephala RHAMNACEAE

Life history

Growth form: Spreading shrub to 3 m high, often multistemmed.
Vegetative spread: No.
Longevity: 10–25 years (N. Walsh pers. comm.).
Primary juvenile period:
Flowers: Yellow, petals absent, September–October. Buds present for many months before flowers open (Harden 2000a).
Fruit/seed: Capsule with long rusty hairs, separating into 3 segments, October.
Dispersal, establishment & growth:
Fire response: Probably killed (N. Walsh pers. comm.).
Interaction with other organisms: Foodplant of butterfly larvae *Hypochrysops byzos* (Braby 2000).

Distribution

Status/origin: Native.
Botanical subregions: NC **CC** SC NT **CT** ST NWS; Vic.
Distribution Sydney area: Mainly at higher altitudes on the ranges.
Select locations: **CC**: Boorai Creek, Lake Burragorang. **CT**: Jenolan Caves, Mt Werong, Canyonleigh.

Habitat

Habitat: Ridges and slopes.
Altitude: 0–1000 m **Annual rainfall:** 800–1400 mm
Typical local abundance:
Vegetation: Open-forest.
Substrate:
Exposure:

Conservation

Conservation: Mainly at higher altitudes on the ranges. Conservation status unknown.

Pomaderris ferruginea RHAMNACEAE

Life history

Growth form: Shrub 1–4 m high, stems with rusty, simple hairs.
Vegetative spread: No.
Longevity: 10–25 years (N. Walsh pers. comm.).
Primary juvenile period: About 3 years after high intensity fire 1/94 (at Lane Cove, P. Kubiak pers. comm.).
Flowers: Yellow, with petals, flowers scented, September–October, peak September. Buds present for many months before flowers open (Harden 2000a). Peak flowering period about 5 years after high intensity fire 1/94 (at Lane Cove); possibly pollinated by native bees, flies, beetles and bugs P. Kubiak pers. comm.).
Fruit/seed: Capsule with long silky hairs, separating into 3 segments, October–November.
Dispersal, establishment & growth: Diaspore: seed, probably with soil-stored seedbank.
Fire response: Killed after high intensity fire 1/94 (at Lane Cove, P. Kubiak pers. comm.).
Interaction with other organisms: Food plant of butterfly larvae *Hypochrysops byzos byzos* (Common & Waterhouse 1981).

Distribution

Status/origin: Native.
Botanical subregions: NC **CC** SC **CT** ST CWS; Qld, Vic.
Distribution Sydney area: Widespread.
Select locations: **CC**: Terrigal, West Head, Narrabeen, Lane Cove, Newington, Casula, Grose Vale, Glenbrook, Werombi, Douglas Park. **CT**: Rylstone, Katoomba, Kanangra, Mt Werong, Penrose.

Habitat

Habitat: Ridges, rocky slopes.
Altitude: 0–1000 m **Annual rainfall:** 800–1400 mm
Typical local abundance: Frequent–occasional.
Vegetation: Open-forest e.g. with *Syncarpia glomulifera, Eucalyptus piperita, Angophora costata, Eucalyptus paniculata, E. punctata*; woodland e.g. with *Eucalyptus eximia, E. gummifera, E. sieberi, E. goniocalyx*; heath e.g. with *Banksia ericifolia*.
Substrate: Sandy loam from shales, conglomerate, sandstone, medium nutrient soils.
Exposure: Mid-shade–light shade.

Conservation

Conservation: Vulnerable in Western Sydney (James et al. 1999), though mainly occurs on margins of Cumberland Plain. Reported in Bouddi NP, Brisbane Water NP, Marramarra NP, Ku-ring-gai Chase NP, Garigal NP, Sydney Harbour NP. Status elsewhere unknown.

Pomaderris intermedia (*P. sieberiana*) RHAMNACEAE

Life history

Growth form: Shrub to 3 m high, with covering of short dense intertwined stellate hairs on stems and undersurface of leaves; simple hairs present also. Intermediates occur between this species and *P. elliptica* (Harden 2000a).
Vegetative spread: No.
Longevity: 10–25 years (N. Walsh pers. comm.).
Primary juvenile period: 3–4 years (L.McD.). Peak flowering period about 5 years after high intensity fire 1/94 (at Lane Cove)(P. Kubiak pers. comm.).
Flowers: Yellow, with petals, September–October. Buds present for many months before flowers open (Harden 2000a). Possibly pollinated by native bees P. Kubiak pers. comm.).
Fruit/seed: Hairy capsule, separating into 3 segments, November–December.
Dispersal, establishment & growth: Diaspore: seed, soil-stored seedbank.
Fire response: Killed, recruitment from soil-stored seed (L.McD.).
Interaction with other organisms: Food plant of butterfly larvae *Hypochrysops byzos byzos* (Common & Waterhouse 1981).

Distribution

Status/origin: Native.
Botanical subregions: NC **CC** SC NT **CT** ST CWS; Vic., Tas.
Distribution Sydney area: Widespread, Coast and Blue Mountains.
Select locations: **CC**: Narara, Woy Woy, Hornsby, Galston, Wahroonga, Bondi, Picnic Point, Liverpool, Helensburgh, Appin, O'Hares Creek. **CT**: Coricudgy, Capertee, Blackheath, Katoomba, Megalong Valley, Colo Vale.

Habitat

Habitat: Steep slopes, near creeks, gullies.
Altitude: 0–1000 m **Annual rainfall:** 800–1400 mm
Typical local abundance: Frequent–occasional.
Vegetation: Open-forest e.g. with *Eucalyptus pilularis, Angophora costata, E. agglomerata, E. piperita*; woodland e.g with *Eucalyptus rossii.*
Substrate: Sandy soil and alluvium, also on shale soils, low nutrients.
Exposure:

Conservation

Conservation: Conservation status unknown. Reported in Brisbane Water NP, Marramarra NP, Garigal NP.

Pomaderris lanigera RHAMNACEAE

Life history

Growth form: Shrub or small tree 1–5 m high; stems covered with rusty curly hairs.
Vegetative spread: No.
Longevity: 10–25 years (N. Walsh pers. comm.).
Primary juvenile period:
Flowers: Golden, with petals, August–October, peak September. Buds present for many months before flowers open (Harden 2000a). Flowers visited by weevils and small flies (P. Kubiak pers. comm.).
Fruit/seed: Hairy capsule, separating into 3 segments, October–November.
Dispersal, establishment & growth: Coloniser species in absence of fire (at Silverwater).
Fire response: Probably killed (N. Walsh pers. comm.).
Interaction with other organisms: Food plant of butterfly larvae *Hypochrysops byzos byzos* (Common & Waterhouse 1981).

Distribution

Status/origin: Native.
Botanical subregions: NC **CC** SC NT **CT** ST NWS CWS; Qld, Vic.
Distribution Sydney area: Coast and ranges.
Select locations: **CC**: Howes Valley, Woy Woy, Cowan, Thornleigh, Silverwater, Wallacia, Leumeah, Kentlyn, Yerranderie, Cataract Dam, Heathcote, Hilltop, Tahmoor, O'Hares Creek. **CT**: Mt Coricudgy, Mt Victoria, Newnes Plateau, Mt Werong, Wingello.

Habitat

Habitat: Gullies, creekbanks.
Altitude: 0–1000 m **Annual rainfall:** 800–1400 mm
Typical local abundance: Frequent.
Vegetation: Open-forest e.g. with *Angophora costata, Eucalyptus agglomerata, E. piperita, E. saligna, Syncarpia glomulifera, Casuarina torulosa, Eucalyptus punctata.*
Substrate: Sandy soil on alluvium and sandstone or occasionally shale, low to medium nutrients.
Exposure:

Conservation

Conservation: Conservation status unknown. Reported in Bouddi NP, Ku-ring-gai Chase NP, Garigal NP, Royal NP, Heathcote NP, Thirlmere Lakes NP.

Pomaderris ledifolia RHAMNACEAE

Life history

Growth form: Erect shrub to 2 m high, sometimes prostrate in extreme conditions; young stems with short whitish simple hairs. Often confused with *P. andromedifolia* (Harden 1990).
Vegetative spread: No.
Longevity: 10–25 years (N. Walsh pers. comm.).
Primary juvenile period:
Flowers: Petals present, September–October. Buds present for many months before flowers open (Harden 2000a).
Fruit/seed: Capsule with long silvery hairs, separating into 3 segments, December.
Dispersal, establishment & growth:
Fire response: Probably killed (N. Walsh pers. comm.).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC **CC** SC **CT** ST; Vic, Qld.
Distribution Sydney area: Woronora Plateau, Blue Mountains.
Select locations: **CC**: Heathcote (1915), Woronora River (1902), Appin (1898), Glen Davis, Hilltop. **CT**: Rylstone, Newnes Plateau, Mt Wilson, Katoomba, Kanangra.

Habitat

Habitat: Rocky hillsides, cliffs.
Altitude: 0–1000 m **Annual rainfall:** 900–1400 mm
Typical local abundance: Frequent–occasional.
Vegetation: Open-forest e.g. with *Eucalyptus piperita, E. sieberi, E. globoidea, Syncarpia glomulifera, Eucalyptus punctata, Corymbia gummifera*; heath e.g. with *Hakea, Eucalyptus stricta.*
Substrate: Sandy soil on sandstone, low nutrients.
Exposure:

Conservation

Conservation: No recent records for Royal National Park–Woronora River area despite a number of collections made between 1893 and 1915. Conservation status unknown.

Pomaderris ligustrina subsp. *ligustrina* RHAMNACEAE

Life history

Growth form: Shrub 1–2 m high, with rusty covering of short dense stellate hairs and long simple hairs.
Vegetative spread: No.
Longevity: 10–25 years (N. Walsh pers. comm.).
Primary juvenile period:
Flowers: Yellow, petals absent, September–October. Buds present for many months before flowers open (Harden 2000a).
Fruit/seed: Capsule 3 mm long with long sivery hairs, separating into 3 segments, with seed 2 mm long, November.
Dispersal, establishment & growth:
Fire response: Probably killed (N. Walsh pers. comm.).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC **CC** SC NT **CT**; Qld, Vic.
Distribution Sydney area:
Select locations: **CC**: Gosford, Narara, Wisemans Ferry, Rookwood, Glen Davis, Kentlyn, Thirlmere, Albion Park, Macquarie Pass. **CT**: Blackheath, Kings Tableland, Hill Top, Bundanoon.

Habitat

Habitat: Slopes, gullies, along creeks.
Altitude: 0–1000 m **Annual rainfall:** 800–1400 mm
Typical local abundance: Occasional.
Vegetation: Moist open-forest e.g. with *Eucalyptus saligna, Syncarpia glomulifera, Angophora costata, A. floribunda*; drier open-forest e.g. with *Eucalyptus punctata, E. sparsifolia, E. racemosa.*
Substrate: Sandy loam on shales, sandstone, low nutrients.
Exposure:

Conservation

Conservation: Conservation status unknown. Reported from Brisbane Water NP.

Pomaderris mediora RHAMNACEAE

Life history

Growth form: Procumbent to erect shrub 1–3 m high, with greyish or rusty simple hairs on young stems.
Vegetative spread: No.
Longevity: 10–25 years (N. Walsh pers. comm.).
Primary juvenile period:
Flowers: Cream, petals absent, September–October (Walsh & Coates 1997). Buds present for many months before flowers open (Harden 2000a).
Fruit/seed: Brown–grey hairy capsule 3 mm long, separating into 3 segments, with seed 3 mm long, mature October–November (Walsh & Coates 1997).
Dispersal, establishment & growth:
Fire response: Probably killed (N. Walsh pers. comm.).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: **CC**.
Distribution Sydney area: Coast, Hawkesbury River to Bulli.
Select locations: **CC**: Turrimetta Head, Whale Beach, Newport, Austinmer, Sublime Point, Lodden Creek.

Habitat

Habitat: Coastal headlands.
Altitude: 20–500 m **Annual rainfall:** 1200–1600 mm
Typical local abundance: Frequent.
Vegetation: Heathland and scrub e.g. with *Westringia fruticosa, Allocasuarina verticillata, Leptospermum laevigatum, Lomandra longifolia.*
Substrate: Sandy to clay soils on sandstones and shales of Narrabeen Group (Walsh & Coates 1997), low nutrients.
Exposure: Full sun.

Conservation

Conservation: Local endemic, with conservation code 2RC in terms of Briggs and Leigh (1988) (Walsh & Coates 1997). The collection at Bluff Track Frenchs Forest (see Walsh & Coates 1997) is on roadside at the end of a cul-de-sac, most probably introduced here in soil fill and now naturalised (L.McD.). Conservation adequacy unknown.

Pomaderris pauciflora RHAMNACEAE

Life history

Growth form: Shrub to 3 m high; stems covered with dense intertwined stellate hairs.
Vegetative spread: No.
Longevity: 10–25 years (N. Walsh pers. comm.).
Primary juvenile period:
Flowers: Creamish, without petals. Buds present for many months before flowers open (Harden 2000a).
Fruit/seed: Hairy capsule, separating into 3 segments.
Dispersal, establishment & growth:
Fire response: Probably killed (N. Walsh pers. comm.).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CT ST CWS; Vic.
Distribution Sydney area: Berrima.
Select locations: CT: Coleby.

Habitat

Habitat:
Altitude: 600–700 m **Annual rainfall:** 900 mm
Typical local abundance:
Vegetation:
Substrate:
Exposure:

Conservation

Conservation: Coded 3RC- on national rare species list (Briggs & Leigh 1996). Coleby is at northern distributional limit. Conservation adequacy unknown.

Pomaderris phylicifolia subsp. *ericoides* RHAMNACEAE

Life history

Growth form: Shrub 1–2 m high.
Vegetative spread: No.
Longevity: 10–25 years (N. Walsh pers. comm.).
Primary juvenile period:
Flowers: Pale yellow, petals absent, September–December. Buds present for many months before flowers open (Harden 2000a).
Fruit/seed: Hairy capsule, separating into 3 segments.
Dispersal, establishment & growth:
Fire response: Probably killed (N. Walsh pers. comm.).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CC SC ST CWS SWS; Vic.
Distribution Sydney area: Ranges south of the Blue Mountains.
Select locations: CC: Bulli. CT: Mt Wilson, Jenolan, Berrima, Barbers Creek, Tuglow Caves, Richlands.

Habitat

Habitat: Hillsides.
Altitude: 0–1000 m **Annual rainfall:** 900–1400 mm
Typical local abundance: Occasional.
Vegetation: Eucalyptus woodland.
Substrate: Sandy stony soils on sandstone, conglomerate, metamorphics, low nutrients.
Exposure:

Conservation

Conservation: Conservation status unknown.

Pomaderris phylicifolia subsp. *phylicifolia* RHAMNACEAE

Life history

Growth form: Shrub 1–2 m high.
Vegetative spread: No.
Longevity: 10–25 years (N. Walsh pers. comm.).
Primary juvenile period:
Flowers: Pale yellow, petals absent. Buds present for many months before flowers open (Harden 2000a).
Fruit/seed: Hairy capsule, separating into 3 segments.
Dispersal, establishment & growth:
Fire response: Probably killed (N. Walsh pers. comm.).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NT CT ST CWS.
Distribution Sydney area: Southern Highlands, Jenolan Caves.
Select locations: CT: Jenolan Caves (1900), Hill Top, Joadja Creek.

Habitat

Habitat:
Altitude: 600–800 m **Annual rainfall:** 900–1000 mm
Typical local abundance:
Vegetation: Dry eucalypt forest.
Substrate: Shallow soils on siltstones, sandstones.
Exposure:

Conservation

Conservation:

Pomaderris precaria RHAMNACEAE

Life history

Growth form: Slender shrub 1–2 m high, with young stems greyish-rusty hairy.
Vegetative spread: No.
Longevity: 10–25 years (N. Walsh pers. comm.).
Primary juvenile period:
Flowers: Yellow, with petals, September–October. Buds present for many months before flowers open (Harden 2000a).
Fruit/seed: Blackish capsule 5 mm long, separating into 3 segments, with seed 2.5 mm long, mature December (Walsh & Coates 1997).
Dispersal, establishment & growth:
Fire response: Probably killed (N. Walsh pers. comm.).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CT CWS.
Distribution Sydney area: Rylstone, Capertee Valley.
Select locations: CT: Rylstone, Mt Gundangaroo.

Habitat

Habitat: Rocky ridges or below cliffs.
Altitude: 700–900 m **Annual rainfall:** 600–700 mm
Typical local abundance: Occasional.
Vegetation: Shrubland or dry eucalypt woodland.
Substrate: Skeletal or gravelly soils derived from sandstone (Walsh & Coates 1997).
Exposure:

Conservation

Conservation: Rare localised species, reported from 2 locations, a roadside and adjacent property at Rylstone and from St Johns Point, Mt Gundangaroo in Wollemi National Park but not collected there since 1966. Recommended code 2VC- (sensu Briggs & Leigh 1989) (Walsh & Coates 1997).

Pomaderris prunifolia var. *prunifolia* RHAMNACEAE

Life history

Growth form: Shrub 1–3 m high; stems covered with rusty stellate hairs.
Vegetative spread: No.
Longevity: 10–25 years (N. Walsh pers. comm.).
Primary juvenile period:
Flowers: Yellow, petals absent, August–October. Buds present for many months before flowers open (Harden 2000a).
Fruit/seed: Capsule, with long rusty hairs, separating into 3 segments.
Dispersal, establishment & growth:
Fire response: Probably killed (N. Walsh pers. comm.).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CC SC NT CT ST NWS CWS; Qld, Vic.
Distribution Sydney area: Bankstown–Dundas, Tablelands.
Select locations: CC: Dundas, Parramatta, Flemington (1898), Bankstown (1920). CT: Mt Darcy, Mt Caley, Mullions Range, Jenolan Caves, Mt Werong, Bundanoon, Barbers Creek.

Habitat

Habitat: Rocky slopes, along creeks.
Altitude: 0–1000 m **Annual rainfall:** 900–1200 mm
Typical local abundance: Occasional.
Vegetation:
Substrate: Sandy soil on sandstone, also recorded on basalt.
Exposure:

Conservation

Conservation: Remaining coastal populations. Plants at Dundas–Parramatta listed as an Endangered Population (Schedule 1) NSW *Threatened Species Conservation Act 1995*. Conservation status of Tablelands population unknown, though no records for Jenolan Caves or Barbers Creek since 1900.

Pomaderris sericea RHAMNACEAE

Life history

Growth form: Low shrub with shining golden-brown hairs on new growth.
Vegetative spread: No.
Longevity: 10–25 years (N. Walsh pers. comm.).
Primary juvenile period:
Flowers: Creamish, no petals. Buds present for many months before flowers open (Harden 2000a).
Fruit/seed: Hairy capsule, separating into 3 segments.
Dispersal, establishment & growth:
Fire response: Probably killed (N. Walsh pers. comm.).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CT; Vic.
Distribution Sydney area: Southern Highlands.
Select locations: Berrima (1889), Bundanoon Creek.

Habitat

Habitat: Lower slopes, below cliffs.
Altitude: 200–600 m **Annual rainfall:** 900–1200 mm
Typical local abundance: Occasional.
Vegetation: Tall open-forest e.g. with *Eucalyptus deanei, Ceratopetalum apetalum.*
Substrate: Sandy soil on sandstone.
Exposure:

Conservation

Conservation: Rare in NSW, collected only from Berrima at the turn of the century (Harden 1990), listed as Endangered (Schedule 1) NSW *Threatened Species Conservation Act 1995* and coded 3VCi on national rare species list (Briggs & Leigh 1996).

Pomaderris subcapitata RHAMNACEAE

Life history

Growth form: Shrub to 2 m high, with hairy stems.
Vegetative spread: No.
Longevity: 10–25 years (N. Walsh pers. comm.).
Primary juvenile period:
Flowers: Yellow, with petals. Buds present for many months before flowers open (Harden 2000a).
Fruit/seed: Hairy capsule with long rusty hairs, separating into 3 segments.
Dispersal, establishment & growth:
Fire response: Probably killed (N. Walsh pers. comm.).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC NT CT ST; Vic.
Distribution Sydney area: Colong Caves.
Select locations: CT: Colong Caves.

Habitat

Habitat: Limestone slopes.
Altitude: 700 m **Annual rainfall:** 800–900 mm
Typical local abundance: Occasional.
Vegetation:
Substrate: Foot of limestone slopes.
Exposure:

Conservation

Conservation: Not common in NSW, only Sydney area record is Colong Caves.

Pomaderris vellea RHAMNACEAE

Life history

Growth form: Erect shrub to 2 m high, with hairy stems.
Vegetative spread: No.
Longevity: 10–25 years (N. Walsh pers. comm.).
Primary juvenile period:
Flowers: Yellow, with petals, November. Buds present for many months before flowers open (Harden 2000a).
Fruit/seed: Hairy capsule, separating into 3 segments.
Dispersal, establishment & growth:
Fire response: Probably killed (N. Walsh pers. comm.).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC CC NT CWS; Qld.
Distribution Sydney area: Campbelltown.
Select locations: CC: Kentlyn.

Habitat

Habitat:
Altitude: 0–100 m **Annual rainfall:** 800 mm
Typical local abundance: Occasional.
Vegetation: Dry open-forest.
Substrate: Sandy soils on sandstone, low nutrients.
Exposure:

Conservation

Conservation: Mainly north from Hunter Valley, Campbelltown is disjunct occurrence at southern limit. Considered vulnerable in Western Sydney (James et al. 1999).

Pomaderris velutina RHAMNACEAE

Life history

Growth form: Slender shrub to 2 m high, young stems with long rusty hairs.
Vegetative spread: No.
Longevity: 10–25 years (N. Walsh pers. comm.).
Primary juvenile period:
Flowers: Pale yellow, petals absent, November. Buds present for many months before flowers open (Harden 2000a).
Fruit/seed: Hairy capsule, separating into 3 segments.
Dispersal, establishment & growth:
Fire response: Probably killed (N. Walsh pers. comm.).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CC ST SWS; Vic., Tas.
Distribution Sydney area: Burragorang–Nattai area.
Select locations: CC: Burragorang, Nattai.

Habitat

Habitat: Slopes.
Altitude: 0–400 m **Annual rainfall:** 800–900 mm
Typical local abundance: Frequent.
Vegetation: Open-forest e.g. with *Allocasuarina torulosa*.
Substrate: Sandy soil on sandstone, low nutrients.
Exposure:

Conservation

Conservation: Not common in NSW, Nattai–Burragorang area, populations are disjunct and at northern geographical limit. Conservation status unknown.

Rhamnus alaternus * RHAMNACEAE

Buckthorn

Life history

Growth form: Tall, evergreen spreading shrub.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Greenish, early spring.
Fruit/seed: Roundish, blue-black, succulent, 3–5 mm diam., usually containing 3 nutlets.
Dispersal, establishment & growth: Diaspore: fruit, probably bird-dispersed.
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to Europe. Introduced as ornamental.
Botanical subregions: CC CT CWS.
Distribution Sydney area:
Select locations: CC: Leumeah (1948), Campbelltown, Nepean River, Cobbitty (1951).
CT: Megalong Creek (1953).

Habitat

Habitat: Creeks and waste places.
Altitude: 0–800 m **Annual rainfall:** 700–1000 mm
Typical local abundance:
Vegetation:
Substrate:
Exposure:

Conservation

Conservation: Cultivated, occasionally naturalised. Not reported along the Nepean River by Benson and Howell (1993).

Acaena agnipila ROSACEAE

Life history

Growth form: Hairy perennial herb 20–50 cm high
Vegetative spread: No.
Longevity:
Primary juvenile period:
Flowers: October–November. Wind-pollinated and likely to be strongly out-crossing (Symon et al. 2000).
Fruit/seed: Spiny burr-like head containing an achene, October–November.
Dispersal, establishment & growth: Diaspore: fruit, dispersed by attachment to fur of animals, clothing etc.
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: **CC** SC NT **CT** ST NWS CWS SWS; Qld, Vic., Tas., S.A., W.A., *NZ
Distribution Sydney area: Western Sydney, Bathurst.
Select locations: **CC**: Rookwood, Camden. **CT**: Sunny Corner, Wattle Flat.

Habitat

Habitat:
Altitude: 0–1000 m **Annual rainfall:** 600–700 mm
Typical local abundance:
Vegetation: Grassland.
Substrate: Clay soils on shales, slates.
Exposure:

Conservation

Conservation: Rare, conservation status unknown, recorded mostly in cemeteries, Not recorded for Western Sydney in James et al. (1999). Possibly confused with *Acaena ovina*.

Acaena echinata ROSACEAE

Life history

Growth form: Perennial herb 25–40 cm high
Vegetative spread: No.
Longevity:
Primary juvenile period:
Flowers: September. Wind-pollinated and likely to be strongly out-crossing (Symon et al. 2000).
Fruit/seed: Spiny burr-like head containing an achene, September–March.
Dispersal, establishment & growth: Diaspore: fruit, dispersed by attachment to fur of animals, clothing etc.
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: **CC** SC ST SWS; Qld, Vic., Tas., S.A., W.A.
Distribution Sydney area: Tablelands and Western Sydney.
Select locations: **CC**: Casula, Narellan, Camden, Menangle. **CT**: Orange, Turondale, Leura.

Habitat

Habitat:
Altitude: 0–1000 m **Annual rainfall:** 700–900 mm
Typical local abundance: Occasional.
Vegetation: Scrub e.g. with *Bursaria spinosa*.
Substrate: Clay soils on shale, slate.
Exposure:

Conservation

Conservation: Conservation status unknown.

Acaena novae-zelandiae ROSACEAE

Life history

Growth form: Creeping perennial herb, with hairy stems and flowers in globular terminal heads.
Vegetative spread: Spreading by stolons.
Longevity:
Primary juvenile period:
Flowers: November–May, peak November. Wind-pollinated and likely to be strongly out-crossing (Symon et al. 2000).
Fruit/seed: Spiny burr-like head 20–25 mm diam., containing an achene, November–May.
Dispersal, establishment & growth: Diaspore: fruit, dispersed by attachment to fur of animals, clothing etc.
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC **CC** SC NT **CT** ST NWS CWS; Qld, Vic., Tas., S.A., N.Z.
Distribution Sydney area: Mainly Tablelands.
Select locations: **CC**: Grose Vale, Yerranderie, Cambewarra Range. **CT**: Nullo Mountain, Mt Canobolas, Cadia, Oberon, Boyd Plateau, Mt Wilson, Katoomba, Barren Grounds, Berrima, Kangaloon.

Habitat

Habitat: Moist places.
Altitude: 300–1200 m **Annual rainfall:** 800–1400 mm
Typical local abundance: Frequent–occasional.
Vegetation: Upland swamp e.g. with *Empodisma minus, Restio australis*; open-forest e.g. with *Eucalyptus macrorhyncha, E. polyanthemos, E. goniocalyx*; woodland e.g. with *Eucalyptus pauciflora, Leptospermum obovatum.*
Substrate: Clay soils on basalt, alluvium, medium to high nutrients.
Exposure:

Conservation

Conservation: Conservation status unknown, many old collections in proportion to recent collections.

Acaena ovina ROSACEAE

Life history

Growth form: Perennial hairy herb. Develops hard woody crowns and roots (Whittet 1958).
Vegetative spread: No.
Longevity:
Primary juvenile period:
Flowers: October–November. Wind-pollinated and likely to be strongly out-crossing (Symon et al. 2000).
Fruit/seed: Spiny burr-like head containing an achene, October–November.
Dispersal, establishment & growth: Diaspore: fruit, dispersed by attachment to fur of animals, clothing etc.
Fire response:
Interaction with other organisms: Young leaves sometimes eaten by sheep but stems unpalatable, enabling plants to develop numerous seed heads carrying hooked seeds which damage fleeces (Whittet 1958).

Distribution

Status/origin: Native.
Botanical subregions: NT **CT** ST CWS SWS; Qld, Vic., Tas., S.A., W.A., *NZ
Distribution Sydney area: Tablelands.
Select locations: **CT**: Rylsone, Orange, Wyagdon, Oberon, Mt Victoria, Moss Vale.

Habitat

Habitat: Grassland, roadsides.
Altitude: 600–1000 m **Annual rainfall:** 800–1000 mm
Typical local abundance: Frequent–occasional.
Vegetation: Grassland.
Substrate: Clay soils on shale, basalt.
Exposure:

Conservation

Conservation: Conservation status unknown.

Aphanes arvensis * ROSACEAE

Parsley-piert

Life history

Growth form: Spreading or erect herb 4–10 cm high.
Vegetative spread: No.
Longevity: Less than 1 year.
Primary juvenile period: Less than 1 year.
Flowers:
Fruit/seed: Achene enclosed in a cup-like structure about 2 mm long.
Dispersal, establishment & growth: Often colonising disturbed areas.
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to Europe.
Botanical subregions: NT CT ST NWS; Vic., Tas.
Distribution Sydney area: Oberon area.
Select locations: CT: Edith (1966).

Habitat

Habitat: Stream bank.
Altitude: 1000–1200 m **Annual rainfall:** 900 mm
Typical local abundance:
Vegetation:
Substrate: Mud on stream bank.
Exposure:

Conservation

Conservation: Minor weed, rarely reported in Sydney area.

Aphanes australiana ROSACEAE

Life history

Growth form: Pale green dwarf herb to 10 cm high.
Vegetative spread: No.
Longevity: Less than 1 year.
Primary juvenile period: Less than 1 year.
Flowers: September–December.
Fruit/seed: Achene enclosed in a cup-like structure 2 mm long.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: CT CWS SWS SWP; Vic., Tas.
Distribution Sydney area: Bathurst (1992).
Select locations: CT: Bathurst.

Habitat

Habitat: Often on rocks.
Altitude: 700–800 m **Annual rainfall:** 600–650 mm
Typical local abundance: Occasional.
Vegetation: Ungrazed pasture e.g. with *Eucalyptus melliodora, E. blakelyi*; in moss mats in forest.
Substrate:
Exposure:

Conservation

Conservation: Appears to be rare, conservation status unknown.

*Duchesnea indica** ROSACEAE

Indian Strawberry

Life history

Growth form: Perennial herb with trifoliate leaves.
Vegetative spread: Spreads by slender stolons.
Longevity: Indefinite.
Primary juvenile period:
Flowers: Yellow, October–April.
Fruit/seed: Fleshy, red, covered with hard achenes. Mature mainly December–January (L. Parkinson pers. comm.). Fruit edible but insipid.
Dispersal, establishment & growth: Rooting fragments probably spread by water. Fruit reported from pellets of Currawongs (Buchanan 1989a).
Fire response: Resprouted after high intensity fire 1/94, secondary juvenile period less than 6 months (at Lane Cove, P. Kubiak pers. comm.).
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to India and Asia. Introduced as ornamental.
Botanical subregions: NC CC CT CWS; LHI, Qld.
Distribution Sydney area: Widespread.
Select locations: CC: Pennant Hills, Wahroonga (1948), Nortons Basin, Fairfield, Albion Park, Upper Kangaroo Valley. CT: Mt Tomah, Robertson.

Habitat

Habitat: Moist sites, creeks.
Altitude: 0–700 m **Annual rainfall:** 900–1400 mm
Typical local abundance: Frequent.
Vegetation: Disturbed rainforest e.g. with *Doryphora sassafras*; riverine vegetation e.g. with *Tristaniopsis laurina, Backhousia myrtifolia, Casuarina cunninghamiana.*
Substrate: Clay soils on shale, basalt, sandy soil on alluvium, medium to high nutrients, poorly drained.
Exposure:

Conservation

Conservation: Garden escape, naturalised near urban areas.

Geum urbanum ROSACEAE

Life history

Growth form: Perennial herb 50–100 cm high, with stem leaves and basal leaves.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Yellow, summer.
Fruit/seed: Head of achenes, each 3–4 mm long with a persistent hooked style elongating to 10 mm long.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC CC SC NT CT ST; Vic., Tas., N & S temp regions.
Distribution Sydney area: Sporadic.
Select locations: CC: Jamberoo, CT: Mt Werong.

Habitat

Habitat: Creekbanks.
Altitude: 0–1000 m **Annual rainfall:** 900–1400 mm
Typical local abundance:
Vegetation:
Substrate:
Exposure:

Conservation

Conservation: Rare, only 2 records for Sydney area, Jamberoo (1899) and Mt Werong (1971). Conservation status unknown.

Potentilla recta * ROSACEAE

Life history

Growth form: Perennial herb 10–70 cm high, with basal and stem leaves.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Yellow,
Fruit/seed: Head of achenes on a fleshy fruit.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to Europe.
Botanical subregions: NT CT ST CWS SWS; Tas.
Distribution Sydney area: Tablelands.
Select locations: CT: Lucknow (1987), Moss Vale (1946).

Habitat

Habitat: Roadsides.
Altitude: 700–800 m **Annual rainfall:** 800–900 mm
Typical local abundance:
Vegetation:
Substrate:
Exposure:

Conservation

Conservation: Minor weed in cooler areas.

Rosa bracteata * ROSACEAE

Macartney Rose

Life history

Growth form: Shrub with looping or scrambling prickly, hairy stems.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: White with large hairy bracts,
Fruit/seed: Large swollen cup ('hip') 20–30 mm long, containing achenes.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to China. Introduced as ornamental.
Botanical subregions: NC CC NT SWS; Qld.
Distribution Sydney area:
Select locations: **CC**: Cooks River (1912), Kembla Grange (1912).

Habitat

Habitat:
Altitude: 0–200 m **Annual rainfall:** 1000–1200 mm
Typical local abundance:
Vegetation:
Substrate:
Exposure:

Conservation

Conservation: Cultivated, represented by a few old records which may be plantings. Recorded from Kembla Grange (1912, 1936, 1967), suggesting that occurrences may be remnants of old plantings rather than truly naturalised.

Rosa rubiginosa * ROSACEAE

Sweet Briar

Life history

Growth form: Erect or scrambling prickly shrub; crushed foliage with sweet apple-like scent.
Vegetative spread: No (McIntyre et al. 1995).
Longevity:
Primary juvenile period:
Flowers: Pink, October–January, peak November.
Fruit/seed: Large red, swollen cup ('hip') 15–20 mm long, containing achenes, November–May.
Dispersal, establishment & growth: Diaspore: fruit, bird-dispersed (Whittet 1958). Coloniser of previously cleared land.
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to Europe.
Botanical subregions: **CC** SC NT **CT** ST NWS CWS SWS NWP SWP; Vic., Tas., S.A.
Distribution Sydney area: Western Sydney, Tablelands.
Select locations: **CC**: Putty Rd, Richmond (1913), Leumeah, Liverpool, Campbelltown, Albion Park, Kowmung River. **CT**: Rylstone, Orange, Kanimbla Valley, Lithgow, Hill Top (1911), Moss Vale.

Habitat

Habitat: Creekbanks, roadsides, ridges, cleared areas.
Altitude: 0–1000 m **Annual rainfall:** 800–1000 mm
Typical local abundance: Frequent–occasional.
Vegetation: Roadside weed vegetation e.g. with *Tagetes minuta*; cleared land; forest e.g. with *Eucalyptus amplifolia, Casuarina glauca*; shrubland e.g. with *Melaleuca styphelioides, Olea europea* subsp. *africana*.

Substrate: Clay soils on shales, alluvium, medium nutrients. Recorded on saline sites in western NSW (Semple 1993).
Exposure:

Conservation

Conservation: Widespread, minor weed of roadsides and cleared areas, not invasive of bushland.

Rubus bellobatus * (misidentified as *R. velox)* **ROSACEAE**

Kittatinny Blackberry

Life history

Growth form: Large semideciduous scrambling shrub with angular canes and stout, recurved prickles.
Vegetative spread: Arching canes root at tip, spreading outwards.
Longevity:
Primary juvenile period:
Flowers:
Fruit/seed: Red–black aggregate fruit of fleshy druplets 10–20 mm diam.
Dispersal, establishment & growth: Fleshy edible fruits or seeds dispersed by animals.
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Exotic, native of N America.
Botanical subregions: CC.
Distribution Sydney area: Sporadic.
Select locations: CC: Bilpin (1998), Longneck Lagoon (1992), Lane Cove River (1991), Field of Mars Park.

Habitat

Habitat: Roadsides, riverbanks.
Altitude: 0–700 m **Annual rainfall:** 800–1100 mm
Typical local abundance: Frequent.
Vegetation:
Substrate: Loamy soils on shale, medium nutrients.
Exposure:

Conservation

Conservation: Rarely naturalised (Harden 1990), though may spread to form local dense thickets. Rate of seed dispersal and establishment unknown. Weed potential unknown.

Rubus discolor * (*R. procerus*) ROSACEAE

Blackberry

Life history

Growth form: Scrambling semideciduous shrub to 2 m high, with long prickles, and extensive rooting system.
Vegetative spread: Roots suckering, stems layering with arching canes.
Longevity: Indefinite.
Primary juvenile period:
Flowers: Pinkish, November–December. Probably pollinated by honeybees, native bees, beetles, flies and butterflies (P. Kubiak pers. comm.).
Fruit/seed: Black aggregate fruit of succulent druplets 10–15 mm long, December–January.
Dispersal, establishment & growth: Fleshy edible fruits or seeds animal-dispersed e.g. foxes, birds.
Fire response: Probably resprouts from base and root suckers.
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to Europe. Widespread weed.
Botanical subregions: CC SC CT ST; Vic., S.A,. W.A.
Distribution Sydney area: Widespread.
Select locations: CC: Hunters Hill, Minto (1963), Mount Annan, Bargo. CT: Newnes Junction, Katoomba (1902), Oberon, Bundanoon.

Habitat

Habitat: Roadsides, disturbed bush, creekbanks, old gardens.
Altitude: 0–1000 m **Annual rainfall:** 700–1400 mm
Typical local abundance: Frequent.
Vegetation: Shrubland e.g. with *Olea europea* subsp. *africana*.
Substrate: Clay soils on shale, gravelly alluvium.
Exposure:

Conservation

Conservation: Widespread weed of disturbed sites and creekbanks. The most common blackberry in NSW (Maguire 1993).

Rubus ellipticus * ROSACEAE

Yellow Raspberry

Life history

Growth form: Erect shrub with arching canes to 2.5 m high, elliptical leaflets, curved prickles to 4 mm long and stiff reddish bristles on canes (Bean 1997).
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: White, July–October.
Fruit/seed: Yellow, aggregate fruit 9 mm diam., mature July–December.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to India, introduced to Australia in 1891 as *Rubus flavus*.
Botanical subregions: NC CC; Qld.
Distribution Sydney area:
Select locations: CC: Gordon (1997, L.McD.), East Killara (1994), Glenbrook Creek (1991).

Habitat

Habitat: Roadside, creekbed.
Altitude: 0–200 m **Annual rainfall:** 900–1400 mm
Typical local abundance: Occasional.
Vegetation: *Eucalyptus pilularis/Angophora costata* open-forest in weedy creekbed e.g. with *Tradescantia fluminensis* (L.McD.). Rainforest margins; cleared or disturbed areas which formerly supported rainforest (Bean 1997).

Substrate: Sandy soil on sandstone, alluvium, shale, roadfill.
Exposure: Full sun–light shade.

Conservation

Conservation: Recently reported as localised groups of 1–2 plants. Weed potential unknown but likely to spread locally. Seed dispersal and establishment unknown.

Rubus hillii *(R. moluccanus)* ROSACEAE

Life history

Growth form: Tall prickly scrambling shrub or climber, canes 2–4 m long.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Pink–red–white, October–May.
Fruit/seed: Red, aggregate fruit of succulent druplets 12 mm diam. Mean fresh weight 200 mg (Westoby et al. 1990), falling away when ripe, December–January.
Dispersal, establishment & growth: Diaspore: fleshy edible fruits, vertebrate-adapted dispersal (Westoby et al. 1990).
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC **CC CT**; Qld, Vic.
Distribution Sydney area: Widespread.
Select locations: **CC**: Gosford, Woy Woy, Wisemans Ferry, Marramarra Creek, Erskine Creek, Bulli Pass, Macquarie Pass, Cambewarra. **CT**: Rylstone, Katoomba Falls, Mt Victoria, Kanangra, Robertson, Bundanoon.

Habitat

Habitat: Sheltered gullies, below waterfalls.
Altitude: 0–1000 m **Annual rainfall:** 1000–1400 mm
Typical local abundance: Frequent–occasional.
Vegetation: Rainforest and moist eucalypt forest e.g. with *Angophora costata, Eucalyptus punctata.*
Substrate: Shale and volcanic soils, sometimes sandstone gullies, medium nutrients. Soil pH 4.5–5.5 (R. Payne pers. comm.).
Exposure: Sheltered gullies, light shade.

Conservation

Conservation: Conservation status unknown. Reported in Bouddi NP, Brisbane Water NP, Marramarra NP, Muogamarra Nature Reserve, Ku-ring-gai Chase NP, Garigal NP, Sydney Harbour NP.

Rubus laciniatus * ROSACEAE

Cut-leaf Blackberry

Life history

Growth form: Stout, much-branched, semideciduous erect or sprawling prickly shrub.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: White to pink.
Fruit/seed: Black, aggregate fruit of succulent druplets
Dispersal, establishment & growth: Fleshy edible fruits or seeds probably animal-dispersed.
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to Europe.
Botanical subregions: NC CC CT; Vic., S.A.
Distribution Sydney area:
Select locations: CC: Wahroonga (1922), Mosman (1916). CT: Mt Wilson (1920).

Habitat

Habitat:
Altitude: 0–1000 m **Annual rainfall:** 1200–1400 mm
Typical local abundance:
Vegetation:
Substrate:
Exposure:

Conservation

Conservation: Doubtfully naturalised in NSW (Harden 1990), Sydney records probably from gardens.

Rubus leightonii * ROSACEAE

Blackberry

Life history

Growth form: Scrambling or trailing semi-deciduous shrub.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: White to bright pink.
Fruit/seed: Black, aggregate fruit of succulent druplets 15 mm long, February.
Dispersal, establishment & growth: Fleshy edible fruits probably dispersed by animals.
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to Europe.
Botanical subregions: CC CT.
Distribution Sydney area: Southern Highlands.
Select locations: CC: Kiama (1964), Kangaroo Valley. CT: Jenolan Caves, Kowmung River (1972), Kanangra-Boyd NP, Robertson (1918), Mittagong.

Habitat

Habitat: Riverflats, clearings.
Altitude: 0–1000 m **Annual rainfall:** 800–1600 mm
Typical local abundance: Frequent.
Vegetation: Riparian scrub e.g. with *Leptospermum* sp., *Bursaria spinosa, Acacia dealbata.*
Substrate: Clay soils on basalt, limestone and gravelly alluvium, medium–high nutrients.
Exposure:

Conservation

Conservation: Not widespread but sometimes locally common (Harden 1990).

Rubus nebulosus (*R.* sp. *A,* closely related to *R. moorei*) ROSACEAE

Green-leaved Bramble, Bush Lawyer

Life history

Growth form: Tall evergreen climber with orange papery bark and prickles on leaves and flower stalks. Domatia and hairs along veins on undersides of leaflets (Bean 1997). Closely related to *Rubus moorei* (Harden 1990).
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: White, August–November.
Fruit/seed: Red fleshy fruit 10 mm diam. , mature November–February.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC **CC** SC NT **CT**; Qld.
Distribution Sydney area:
Select locations: **CC**: Gosford, Kincumber, Kurrajong Heights, Royal NP, Otford, Mt Kembla, Cambewarra, Minnamurra Falls. **CT**: Robertson, Burrawang.

Habitat

Habitat: Gullies, gorges.
Altitude: 0–600 m **Annual rainfall:** 1200–1600 mm
Typical local abundance: Occasional.
Vegetation: Warm temperate–cool temperate rainforest e.g. with *Doryphora sassafras, Ceratopetalum apetalum, Eupomatia laurina;* swamp forest e.g. with *Melaleuca biconvexa.*
Substrate: Clay soils on basalt, sandy soils on alluvium, sandstone.
Exposure:

Conservation

Conservation: Conservation status unknown.

Rubus parvifolius ROSACEAE

Native Raspberry

Life history

Growth form: Scrambling shrub with stems to 1 m long; hybridizes with *R. hillii.*
Vegetative spread: Yes.
Longevity: Indefinite.
Primary juvenile period:
Flowers: Red or pink, recorded for all months of the year (Bean 1997).
Fruit/seed: Red, aggregate fruit 10 mm diam., of succulent druplets, mature November–April. Fruit weight 285 mg, with c. 14 seeds per fruit (extra data on seed & pulp characteristics in French 1991).
Dispersal, establishment & growth: Diaspore: attractive fleshy edible fruits, vertebrate-adapted dispersal (Westoby et al. 1990).
Fire response: Probably resprouts.
Interaction with other organisms: Adult jewel beetles *Alcinous nodosus* observed during early summer on leaves; larvae feed in the stems and later pupate in a hollowed out chamber (Hawkeswood 1987).

Distribution

Status/origin: Native.
Botanical subregions: NC CC SC NT CT ST NWS CWS; Qld, Vic., Tas., S.A., E Asia.
Distribution Sydney area: Widespread.
Select locations: CC: Wisemans Ferry, Beecroft, Razorback, Campbelltown, Minnamurra, Shellharbour, Barrengarry. CT: Orange, Jenolan Caves, Bundanoon.

Habitat

Habitat: Levee banks.
Altitude: 0–800 m **Annual rainfall:** above 700 mm
Typical local abundance: Frequent.
Vegetation: Riverflat forest e.g. with *Tristaniopsis laurina*, and dry rainforest.
Substrate: Sandy alluvial soils and clay soils from shale, basalt, medium–high nutrients.
Exposure: Mid-shade.

Conservation

Conservation: Conservation status unknown. Reported in Brisbane Water NP, Marramarra NP, Dalrymple Hay Nature Reserve.

Rubus radula * ROSACEAE

Blackberry

Life history

Growth form: Scrambling semideciduous shrub with arching or trailing stems tips that root when in contact with the ground.
Vegetative spread: Stems tips root when in contact with the ground.
Longevity:
Primary juvenile period:
Flowers: White or pinkish, December.
Fruit/seed: Black aggregate fruit of succulent druplets
Dispersal, establishment & growth: Fleshy edible fruits or seeds probably dispersed by animals.
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to Europe.
Botanical subregions: CC.
Distribution Sydney area:
Select locations: CC: Bargo (1953).

Habitat

Habitat:
Altitude: 400 m **Annual rainfall:** 900 mm
Typical local abundance:
Vegetation:
Substrate:
Exposure:

Conservation

Conservation: Not widespread (Harden 1990), only Sydney record is Bargo (1953).

Rubus roribaccus * ROSACEAE

North American Dewberry

Life history

Growth form: Vigorous semideciduous climber with prickles, with low, spreading habit.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: White, September–October.
Fruit/seed: Purple to black oblong fleshy fruit.
Dispersal, establishment & growth: Attractive fleshy edible fruits or seeds dispersed by animals.
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to N America.
Botanical subregions: CC.
Distribution Sydney area: Mainly Sydney suburbs.
Select locations: CC: Yarramalong (1994), Cheltenham (1946), Killara, Lane Cove River, Wentworthville (1957).

Habitat

Habitat: Wasteland, disturbed area.
Altitude: 0–200 m **Annual rainfall:** 900–1400 mm
Typical local abundance: Occasional.
Vegetation: Exotic weeds.
Substrate: Medium nutrient soils on alluvium, shale.
Exposure: Full sun.

Conservation

Conservation: Not widely naturalised (Harden 1990). Weed potential unknown.

Rubus rosifolius var. *commersonii* ROSACEAE

Rose-leaf Bramble

Life history

Growth form: Shrub with trailing glandular-hairy stems to 2 m long and stout curved to almost straight prickles. Distinguished from *R. rosifolius* var. *rosifolius* by the number of petals (Bean 1997).
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: White, with 9–13 petals, June to December.
Fruit/seed: Egg-shaped red fleshy fruit 20 mm long, edible but insipid, mature July to December.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC **CC**; Qld, Java, Mauritius, China, Brazil.
Distribution Sydney area: Sporadic.
Select locations: **CC**: Point Clare (1897), Yellow Rock (1942).

Habitat

Habitat:
Altitude: 0–300 m **Annual rainfall:** 1200 mm
Typical local abundance:
Vegetation: Rainforest margins; wet eucalypt forest
Substrate:
Exposure:

Conservation

Conservation: Rare, reported from only 2 locations in Sydney area. Last recorded in 1942. Kiama is southern geographical limit (Harden 2000).

Rubus rosifolius var. *rosifolius* ROSACEAE

Rose-leaf Bramble

Life history

Growth form: Shrub with trailing glandular-hairy stems to 2 m long and stout curved to almost straight prickles. Distinguished from *R. rosifolius* var. *commersonii* by the number of petals (Bean 1997).
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: White, with 5 petals, June to December.
Fruit/seed: Egg-shaped red fleshy fruit 20 mm long, edible but insipid, mature July to December.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC **CC** SC NT **CT**; Qld, Vic., SE Asia, N.G.
Distribution Sydney area: Widespread on coast and ranges.
Select locations: **CC**: Audley, Albion Park. **CT**: Mount Wilson.

Habitat

Habitat: Creeks, often in disturbed areas.
Altitude: 0–1000 m **Annual rainfall:** 1000–1400 mm
Typical local abundance: Frequent.
Vegetation: Rainforest margins; wet eucalypt forest
Substrate: Probably clayey soils, medium nutrients.
Exposure:

Conservation

Conservation: Reported in Royal NP. Conservation status unknown.

Rubus ulmifolius * ROSACEAE

Blackberry

Life history

Growth form: Semideciduous scrambling shrub with strong hooked prickles. Hybrids are widespread, extensively naturalised and often quite variable; crosses with *R. vestitus* and *R. discolor* are common (Harden 1990).
Vegetative spread: By layering of arching canes.
Longevity:
Primary juvenile period:
Flowers: Pink, December–February.
Fruit/seed: Aggregate black fleshy fruit, often imperfectly formed, February. Sweet and lacking acidity but rather insipid.
Dispersal, establishment & growth: Diaspore: fruit, animal-dispersed.
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Naturalised exotic, native to Europe.
Botanical subregions: **CC** SC NT **CT** ST SWP; Vic.
Distribution Sydney area: Tablelands.
Select locations: **CC**: Albion Park (1949). **CT**: Orange, Evans Plains (1976), Tuglow Caves, Robertson (1917).

Habitat

Habitat: Riverflats, old pastures.
Altitude: 600–1000 m **Annual rainfall:** 600–1600 mm
Typical local abundance: Frequent.
Vegetation: Riparian scrub e.g. with *Leptospermum* sp., *Acacia dealbata, Bursaria spinosa.*
Substrate: Clay soils on shales, gravelly alluvium, medium nutrients.
Exposure:

Conservation

Conservation: Conservation impact unknown.

Rubus vestitus * ROSACEAE

Blackberry

Life history

Growth form: Semideciduous scrambling shrub with red-brown, angled canes and small prickles.
Vegetative spread: By layering of arching canes.
Longevity:
Primary juvenile period:
Flowers: Deep to pale pink.
Fruit/seed: Aggregate black fleshy fruit 10 mm long
Dispersal, establishment & growth: Diaspore: fruit, animal-dispersed.
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to Europe.
Botanical subregions: **CT** ST; Vic.
Distribution Sydney area: Mount Tomah.
Select locations: **CT**: Mount Tomah (1952, 1968), Newnes Junction (1975).

Habitat

Habitat: Remnant forest, roadsides.
Altitude: 1000 m **Annual rainfall:** 1200 mm
Typical local abundance: Frequent.
Vegetation: Moist open-forest e.g. with *Eucalyptus fastigata, Acacia melanoxylon.*
Substrate: Clay soils on basalt, high nutrients.
Exposure:

Conservation

Conservation: Apparently locally naturalised and common over quite a large area (on Mount Tomah South, 1968). Situation now unknown.

Asperula conferta RUBIACEAE

Common Woodruff

Life history

Growth form: Erect to decumbent perennial herb, with stems to 20 cm long.
Vegetative spread: Yes (McIntyre et al. 1995), rhizomatous.
Longevity:
Primary juvenile period:
Flowers: White, October–December.
Fruit/seed: Black-brown fleshy fruit 3–4 mm long, December–January.
Dispersal, establishment & growth: No particular mechanism for dispersal (McIntyre et al. 1995).
Fire response:
Interaction with other organisms: Palatable to rabbits (Leigh et al. 1987).

Distribution

Status/origin: Native.
Botanical subregions: NC **CC** SC NT **CT** ST NWS CWS SWS NWP SWP NFWP; Qld, Vic., N.T., S.A.
Distribution Sydney area:
Select locations: **CC**: St Marys, Marayong, Silverdale, Mount Annan, Camden Park.
CT: Towinhingy, Orange Wyagdon, Limekilns, Bathurst, Moss Vale.

Habitat

Habitat: Open areas.
Altitude: 0–1000 m **Annual rainfall:** 600–1000 mm
Typical local abundance: Frequent.
Vegetation: Eucalypt open-forest, woodland, grassland e.g. with *Themeda australis*.
Substrate: Clay soils on shale, basalt, slate, medium nutrients, well-drained.
Exposure:

Conservation

Conservation: Conserved in Western Sydney (James et al. 1999), conservation elsewhere unknown.

Asperula gunnii RUBIACEAE

Mountain Woodruff

Life history

Growth form: Ascending to decumbent perennial herb, with stems to 20 cm long, conspicuously ridged.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: White, October–March.
Fruit/seed: Black fleshy fruit 1–2 mm long.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC **CT** ST; Vic., Tas., S.A.
Distribution Sydney area: Upper Blue Mountains, Southern Highlands.
Select locations: **CT**: Lithgow, Leura, Boyd Plateau, Mt Werong, Wingecarribee Swamp.

Habitat

Habitat: Damp sites.
Altitude: 700–1200 m **Annual rainfall:** 1100–1600 mm
Typical local abundance: Frequent.
Vegetation: Montane peatland, sedgeland e.g. with *Carex appressa, Carex gaudichaudeana, Xyris ustulata*.
Substrate: Peaty soils, low nutrients, poorly-drained.
Exposure:

Conservation

Conservation: Conservation status unknown.

Asperula scoparia RUBIACEAE

Prickly Woodruff

Life history

Growth form: Ascending or decumbent perennial herb, with hairy stems to 15 cm long, forming loose mats.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: White, with male and female flowers, September–November.
Fruit/seed: Dark brown fleshy fruit 2 mm long.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NT **CT** ST: Vic., Tas., S.A.
Distribution Sydney area: Western Blue Mountains, Southern Highlands.
Select locations: **CT**: Orange, Mt Cameron, Mt Wilson, Jenolan SF, Hampton, Kanangra, Bindook, Robertson.

Habitat

Habitat: Open-forest, moist places.
Altitude: 700–1200 m **Annual rainfall:** 1100–1600 mm
Typical local abundance: Frequent–occasional.
Vegetation: Open-forest e.g. with *Eucalyptus sieberi, E. oreades, E. blaxlandii, E. ovata, E. radiata, E. viminalis.*
Substrate: Clay soil on basalt, shales, medium to high nutrients.
Exposure: Light shade to mid shade.

Conservation

Conservation:

Canthium coprosmoides RUBIACEAE

Coast Canthium

Life history

Growth form: Small tree or shrub to 10 m high, often with domatia in leaf axils.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: White, tubular. January–February.
Fruit/seed: Red fleshy fruit 10 mm diam.
Dispersal, establishment & growth: Fleshy fruit adapted for vertebrate dispersal (Westoby et al. 1990).
Fire response: Resprouts from base (L.McD).
Interaction with other organisms: Larval food plant of bee-hawk moth *Cephonodes kingii* (Common 1990). Poisonous to stock (Hurst 1942).

Distribution

Status/origin: Native.
Botanical subregions: NC CC NT; Qld.
Distribution Sydney area: Coast, north from Gerringong.
Select locations: CC: Parnell (Yengo NP), Mona Vale, Otford, Bass Point, Minnamurra Falls, Foxground.

Habitat

Habitat: Gullies, steep ocean foreshores.
Altitude: 0–400 m **Annual rainfall:** 1000–1600 mm
Typical local abundance: Frequent–occasional.
Vegetation: Littoral rainforest e.g. with *Livistona australis, Eucalyptus botryoides*; subtropical and warm temperate rainforest e.g. with *Ceratopetalum apetalum, Tristaniopsis laurina, Doryphora sassafras*, moist eucalypt forest.
Substrate: Sandy or clay soils on shales, medium nutrients, well-drained. Soil pH 4.5–5.5 (R. Payne pers. comm.).
Exposure: Sheltered.

Conservation

Conservation: Foxground is southern geographical limit. Conservation status unknown. Reported in Yengo NP, Wambina NR.

Coprosma hirtella RUBIACEAE

Life history

Growth form: Erect shrub to 2 m high, with rigid branches.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Male and female flowers in separate clusters.
Fruit/seed: Orange-red fleshy fruit 8–10 mm wide, October.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms: Grazed by stock.

Distribution

Status/origin: Native.
Botanical subregions: SC NT CT ST; Vic., Tas.
Distribution Sydney area: Tablelands.
Select locations: CT: Nullo Mountain, Mt Coricudgy, Sunny Corner, Browns Gap, Jenolan Caves, Blackheath, Leura, Mt Werong, Wombeyan Caves Road.

Habitat

Habitat: Rocky hillsides.
Altitude: 700–1200 m **Annual rainfall:** 900–1400 mm
Typical local abundance: Frequent–occasional.

Vegetation: Woodland e.g. with *Eucalyptus viminalis, E. pauciflora.*
Substrate: Sandy soil on granite, sandstone, basalt.
Exposure:

Conservation

Conservation: Conservation status unknown, reported from Leura–Mt Victoria area 1896–1914 but not reported since.

Coprosma quadrifida RUBIACEAE

Prickly Currant Bush

Life history

Growth form: Slender shrub 2–4 m high, with hairy, often spinescent branches.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Separate male and female flowers, white, September–November.
Fruit/seed: Red fleshy fruit 5 mm long (fruit weight 44 mg), with 2 seeds per fruit (extra data on seed & pulp characteristics in French 1991), December–February.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms: Berries eaten by Yellow-faced Honeyeater *Lichenostomus chrysops* (Barker & Vestjens 1990). Larval food plant of hawk moth *Cizara ardenia* (Common 1990).

Distribution

Status/origin: Native.
Botanical subregions: NC **CC** SC NT **CT** ST; Vic., Tas.
Distribution Sydney area:
Select locations: **CC**: Bulli, Cordeaux Dam, Mt Kembla, Brogers Creek. **CT**: Mt Coricudgy, Orange, Mt Wilson, Mount Tomah, Mt Victoria, Wombeyan Caves, Bundanoon.

Habitat

Habitat: Stream banks, gullies.
Altitude: 0–1000 m **Annual rainfall:** 900–1400 mm
Typical local abundance: Frequent–occasional.
Vegetation: Rainforest e.g. with *Doryphora sassafras, Acacia melanoxylon, Hedycarya angustifolia*; gully forest e.g. with *Eucalyptus fastigata*; open-forest e.g. with *Eucalyptus dalrympleana, E. pauciflora, E. dives*; riparian scrub e.g. with *Backhousia myrtifolia.*
Substrate: Clay soils on basalt, Devonian sediments, gravelly alluvium, medium to high nutrients.
Exposure:

Conservation

Conservation: Conservation status unknown.

Coprosma repens * RUBIACEAE

Looking-glass Bush

Life history

Growth form: Prostrate shrub to small tree to 8 m high.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: September–early November (Price).
Fruit/seed: Orange-red fleshy fruit 10 mm long, December–March.
Dispersal, establishment & growth: Bird and animal-dispersed (Carr et al 1992), possibly seawater-dispersed.
Fire response:
Interaction with other organisms: Larval food plant of hawk moths *Macroglossum hirundo* subsp. *errans* and *Cizara ardenia* (Common 1990).

Distribution

Status/origin: Exotic, native to New Zealand, probably introduced as ornamental.
Botanical subregions: CC SC; Vic., Tas., S.A.
Distribution Sydney area: Coast south of Broken Bay.
Select locations: CC: Curl Curl, Harbord Beach (1963), Bass Point, Stanwell Park (1955), Gerringong Beach (1941), Kiama, Stack Island –Minnamurra River (1939).

Habitat

Habitat: Headlands, cliff faces near the sea.
Altitude: 0–200 m **Annual rainfall:** 1200–1600 mm
Typical local abundance: Frequent.
Vegetation: Scrub, remnant rainforest.
Substrate: Clay soil on latite, sandstone cliffs, rock crevices.
Exposure:

Conservation

Conservation: Naturalised along coast south of Broken Bay, invading undisturbed native vegetation. Appears to have established in 1950s–1970s.

Galium aparine * RUBIACEAE

Goosegrass, Cleavers

Life history

Growth form: Scrambling or twining herb, with prickles.
Vegetative spread: No.
Longevity: Less than one year.
Primary juvenile period: Less than one year.
Flowers: Whitish, November.
Fruit/seed: Dry fruit 3–5 mm long, breaks into 2 1-seeded segments, November.
Dispersal, establishment & growth: Diaspore: fruit, probably dispersed by adhesion to clothing (P. Kubiak pers. comm.).
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to Europe.
Botanical subregions: NC CC SC CT ST NWS SWS SWP NFWP; Qld, Vic., Tas., N.T., S.A.
Distribution Sydney area: Mainly Tablelands.
Select locations: CC: Flemington Saleyard (1968). CT: Jenolan Caves (1967), Junction Reefs (1991), East Kangaloon–Robertson (1987).

Habitat

Habitat: Disturbed sites, pastures.
Altitude: 0–800 m **Annual rainfall:** 800–1600 mm
Typical local abundance: Frequent.
Vegetation: Disturbed sites e.g. with remnant *Eucalyptus melliodora*, pastures.
Substrate: Rock rubble and subsoil.
Exposure:

Conservation

Conservation: Reported naturalised on Tablelands since 1960s. Only record for coast is a single plant at Flemington Saleyard, probably intoduced with stock, and now extinct there.

Galium binifolium RUBIACEAE

Life history

Growth form: Straggling or clambering annual or biennial herb with stems 20-50 cm long.
Vegetative spread: No.
Longevity: Short.
Primary juvenile period:
Flowers: Cream to yellowish, often with a reddish or purplish tinge, September–January.
Fruit/seed: Dry fruit 1.5 mm long, breaks into 2, 1-seeded segments, November–May. Seed weight 0.5 mg (Westoby et al. 1990).
Dispersal, establishment & growth: Diaspore: seed, with no special morphology for dispersal (Westoby et al. 1990).
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC **CC** SC NT **CT** NWS CWS; Vic., S.A.
Distribution Sydney area: Widespread.
Select locations: **CC**: Parnell, Drews Creek, Pymble, Bilpin, Ingleburn, Mulgoa, The Oaks, Mount Annan, Albion Park. **CT**: Newnes, Bindook, Katoomba.

Habitat

Habitat: Slopes, near creeks, entangled in herbage or trailing over rocks.
Altitude: 0–1000 m **Annual rainfall:** 700–1400 mm
Typical local abundance: Rare–occasional.
Vegetation: Open-forest e.g. with *Eucalyptus saligna*; woodland e.g. with *Eucalyptus sieberi, E. blaxlandii.*
Substrate: Clay soils on Wianamatta Shale, basalt, sandstone, medium nutrients.
Exposure:

Conservation

Conservation: Vulnerable in Western Sydney (James et al. 1999). Conservation status elsewhere unknown. Reported in Yengo NP, Brisbane Water NP, Ku-ring-gai Chase NP.

Galium ciliare RUBIACEAE

Life history

Growth form: Prostrate, trailing herb with stems 10–30 cm long.
Vegetative spread: Yes (McIntyre et al. 1995), rhizomatous.
Longevity:
Primary juvenile period:
Flowers: Yellow to cream, November.
Fruit/seed: Dry fruit 1 mm long, breaks into 2 1-seeded segments.
Dispersal, establishment & growth: No particular mechanism for dispersal (McIntyre et al. 1995).
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC NT **CT** ST; Qld, Vic., Tas.
Distribution Sydney area: Upper Blue Mountains.
Select locations: **CT**: Mt Tomah, Mt Wilson, Jenolan River, Hartley Vale.

Habitat

Habitat:
Altitude: 700–1000 m. **Annual rainfall:** 900–1400 mm
Typical local abundance: Frequent.
Vegetation: Grassland and woodland e.g. with *Eucalyptus mannifera, E. radiata, E. piperita.*
Substrate: Basaltic soils or Permian sediments, medium to high nutrients.
Exposure:

Conservation

Conservation: Conservation status unknown.

Galium gaudichaudii RUBIACEAE

Rough Bedstraw

Life history

Growth form: Straggling to trailing perennial herb with numerous erect stems to 30 cm long.
Vegetative spread: Root system with strong primary root and weak development of nodal roots up to 5 cm from the rootstock.
Longevity:
Primary juvenile period:
Flowers: Cream, purplish in bud, September–November.
Fruit/seed: Dry fruit 1–2 mm long, breaks into 2, 1-seeded segments 1.5 mm long, mature September–November.
Dispersal, establishment & growth: No particular mechanism for dispersal (McIntyre et al. 1995).
Fire response: Possibly resprouts.
Interaction with other organisms: Palatable to rabbits (Leigh et al. 1987).

Distribution

Status/origin: Native.
Botanical subregions: **CC** NT **CT** ST NWS CWS SWS NWP SWP; Qld, Vic., Tas., N.T., S.A., W.A.
Distribution Sydney area: Cumberland Plain, Western Blue Mountains.
Select locations: **CC**: Watagan SF, Vineyard, St Marys, Glenfield, Bringelly. **CT**: Limekilns, Mt Canobolas, Capertee, Glen Davis, Kowmung, Abercrombie Caves (McGillivray, 1983), Wombeyan Caves.

Habitat

Habitat: Often on steep hillsides, in grassland.
Altitude: 0–1000 m **Annual rainfall:** 700–1200 mm
Typical local abundance: Occasional–rare.
Vegetation: Eucalypt open-forest, woodland with grassy understorey e.g. with *Eucalyptus moluccana, E. tereticornis, E. rossii.*
Substrate: Usually occurring on relatively dry sites. Gravelly clay or rocky soils from Wianamatta Shale, limestone, sandstone or basalt, medium to high nutrients, well-drained.
Exposure: Sheltered, mid-shade.

Conservation

Conservation: Vulnerable in Western Sydney (James et al. 1999). Conservation status elsewhere unknown.

Galium liratum RUBIACEAE

Life history

Growth form: Creeping or procumbent herb with several stems 15–30 cm long.
Vegetative spread:
Longevity: Short.
Primary juvenile period:
Flowers: White, August.
Fruit/seed: Dry fruit 1.3 mm long, breaks into 2 1-seeded segments, January–April.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: **CC** SC NT **CT** ST CWS; Vic.
Distribution Sydney area:
Select locations: **CC**: Putty Road, Muogamurra NR, Armour Range, Euroka Creek, Glenbrook, Nortons Basin, Douglas Park.

Habitat

Habitat: Moist rocky sites, along creeks.
Altitude: 0–400 m **Annual rainfall:** 900–1000 mm
Typical local abundance:
Vegetation: Eucalypt open-forest or woodland, marshy meadow e.g. with *Persicaria, Leptospermum polygalifolium.*
Substrate: Sandstone or granite rocks, slate, low nutrients.
Exposure: Mid shade.

Conservation

Conservation: Conservation status unknown. Reported in Muogamarra Nature Reserve.

Galium migrans RUBIACEAE

Life history

Growth form: Prostrate to decumbent perennial herb, with numerous stems 20–40 cm long.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Cream to yellowish or white, October.
Fruit/seed: Dry fruit 1–2 mm long, breaks into 2 1-seeded segments, March.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC CC SC NT; Qld, Vic., S.A., W.A.
Distribution Sydney area:
Select locations: **CC**: Nortons Basin, Razorback, Albion Park, Cobbitty. **CT**: Mt Towinhingy, Wyagdon, Winburndale NR, Jenolan Caves, Abercrombie Caves.

Habitat

Habitat: Rocky crevices, near creeks.
Altitude: 0–1000 m **Annual rainfall:** 700–1000 mm
Typical local abundance: Frequent–occasional.
Vegetation: Dry rainforest e.g. with *Streblus brunonianus, Notelaea* sp.
Substrate: Rocky crevices on limestone, granite, occasionally sandstone.
Exposure:

Conservation

Conservation: Conservation status unknown. Reported in Winburndale Nature Reserve.

Galium murale * RUBIACEAE

Small Bedstraw

Life history

Growth form: Small prostrate to ascending herb, with thread-like stems less than 12 cm long.
Vegetative spread:
Longevity: Less than one year.
Primary juvenile period: Less than one year.
Flowers: White to yellowish green, October.
Fruit/seed: Dry fruit 1–1.5 mm long, breaks into 2 1-seeded segments.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to Europe.
Botanical subregions: CC CT ST NWS CWS SWS NWP NFWP; Vic., N.T., S.A., W.A.
Distribution Sydney area:
Select locations: CC: Albion Park (1948). CT: Bathurst (1965).

Habitat

Habitat: Moist sites, pastures, rocky hillsides.
Altitude: 0–700 m **Annual rainfall:** 600–1200 mm
Typical local abundance: Frequent.
Vegetation: Eucalypt open-forest and woodland.
Substrate:
Exposure:

Conservation

Conservation: Sporadically naturalised, with few Sydney records.

Galium propinquum RUBIACEAE

Maori Bedstraw

Life history

Growth form: Prostrate to weakly decumbent herb with stems to 30 cm long and well-developed slender rhizomes.
Vegetative spread: Yes (McIntyre et al. 1995), rhizomatous.
Longevity:
Primary juvenile period:
Flowers: White to cream, October–December.
Fruit/seed: Dry fruit 1 mm long, breaks into 2 1-seeded segments, January–March. Seed weight 0.5 mg (Westoby et al. 1990).
Dispersal, establishment & growth: Diaspore: seed, with tiny hooks presumably for dispersal by attachment to animals (Westoby et al. 1990).
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC CC SC NT CT ST SWS; Qld, Vic., N.Z.
Distribution Sydney area:
Select locations: CC: Culoul Range, Wahroonga, Razorback, The Oaks, Springwood, Mt Keira. CT: Mt Tomah, Hartley Vale, Katoomba, Mt Werong, Fitzroy Falls.

Habitat

Habitat: Moist shady sites, hillsides, creekbanks.
Altitude: 0–1000 m **Annual rainfall:** 700–1400 mm
Typical local abundance: Frequent–occasional.
Vegetation: Rainforest or moist sclerophyll forest e.g. with *Syncarpia glomulifera, Eucalyptus pilularis, Backhousia myrtifolia, Acmena smithii, Eucalyptus obliqua.*
Substrate: Clay soil on basalt, shale, alluvium, medium to high nutrients.
Exposure:

Conservation

Conservation: Conservation status unknown. Reported in Brisbane Water NP, Muogamarra Nature Reserve.

Galium tricornutum * RUBIACEAE

Life history

Growth form: Scrambling herb, with stoutish stems to 1 m long.
Vegetative spread: No.
Longevity: Less than one year.
Primary juvenile period: Less than one year.
Flowers: Whitish.
Fruit/seed: Dry fruit 3–5 mm wide, breaks into 2, 1-seeded segments.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to Europe and Asia.
Botanical subregions: NC **CC CT** CWS; Qld, Vic., S.A., W.A.
Distribution Sydney area:
Select locations:

Habitat

Habitat:
Altitude: **Annual rainfall:**
Typical local abundance:
Vegetation:
Substrate:
Exposure:

Conservation

Conservation: Reported as a weed of cultivated land and rubbish tips in NSW but no records of this being naturalised in Sydney area.

Morinda jasminoides RUBIACEAE

Life history

Growth form: Woody climber or scrambling shrub, with opposite leaves and often, pit-like pouches (domatia) in vein axils.
Vegetative spread: No.
Longevity:
Primary juvenile period:
Flowers: Cream, orange, white–purplish, October–December, peak November.
Fruit/seed: Orange, multiple fleshy fruit 6–15 mm diam., mean fresh weight 300 mg, February–June.
Dispersal, establishment & growth: Diaspore: orange fleshy fruit, vertebrate-adapted dispersal (Westoby et al. 1990). Fruit reported from Currawong pellets (Buchanan 1989a). Fruit eaten by Grey-headed Flying Fox *Pteropus poliocephalus* (Eby 1995).
Fire response: Resprouted after high intensity fire (1/1994) at Lane Cove, fruiting in less than 2 years (P. Kubiak pers. comm.).
Interaction with other organisms: Fruit eaten by Grey-headed Flying Fox *Pteropus poliocephalus* (Eby 1995). Larval food plant of hawk moths *Macroglossum hirundo* subsp. *errans* and *Cizara ardenia* (Common 1990). Pollen gathered by honeybee (P. Kubiak pers. comm.).

Distribution

Status/origin: Native.
Botanical subregions: NC **CC** SC NT **CT**; Qld, Vic.
Distribution Sydney area: Widespread, Coast and lower mountains.
Select locations: **CC**: Mangrove Creek, Sackville, Barrenjoey, Ryde, Kogarah, Campbelltown, Audley, Mt Kembla, Shellharbour, Glenbrook. **CT**: Robertson.

Habitat

Habitat: Creek banks, gullies.
Altitude: 0–800 m **Annual rainfall:** 800–1400 mm
Typical local abundance: Occasional.
Vegetation: Moist rainforest e.g. with *Doryphora sassafras, Ceratopetum apetalum, Acmena smithii*; dry rainforest e.g. with *Streblus brunonianus*; riparian scrub e.g. with *Acmena smithii, Rapanea variabilis*; moist eucalypt forest e.g. with *Eucalyptus pipularis*.
Substrate: Clay soils on basalt, volcanic necks, shales, alluvium, medium to high nutrients.
Exposure: Sheltered sites, light shade–mid-shade.

Conservation

Conservation: Probably adequately conserved. Reported in Bouddi NP, Brisbane Water NP, Muogamarra Nature Reserve, Ku-ring-gai Chase NP, Garigal NP, Sydney Harbour NP.

Opercularia aspera RUBIACEAE

Coarse Stinkweed

Life history

Growth form: Prostrate to erect subshrub to 2 m high, with foetid odour when crushed or picked.
Vegetative spread: No.
Longevity:
Primary juvenile period:
Flowers: September–October.
Fruit/seed: Compound capsule 5–10 mm diameter, releasing seeds at maturity (most of the year). Seed weight 0.5 mg (Westoby et al. 1990).
Dispersal, establishment & growth: Diaspore: seed, ant-adapted food body for dispersal (Westoby et al. 1990). Plants to 2 m high on better soils, less than 0.5 m on sandstone soils. Coloniser.
Fire response: Resprouted after high intensity fire (1/1994) at Lane Cove and Narrabeen, with some plants fruiting in less than 33 weeks (P. Kubiak pers. comm.).
Interaction with other organisms: A few plants eaten by rabbits (P. Kubiak pers. comm.).

Distribution

Status/origin: Native.
Botanical subregions: NC **CC** SC NT **CT** ST NWS CWS; Qld, Vic.
Distribution Sydney area: Widespread.
Select locations: **CC**: Howes Valley, Colo River, Gunderman, Hornsby, Farm Cove (1902), Kurnell, Doonside, Elderslie, Thirlmere, O'Hares Creek, Berry. **CT**: Mt Coricudgy.

Habitat

Habitat: Sandy creekbanks and gullies.
Altitude: 0–800 m **Annual rainfall:** above 700 mm
Typical local abundance: Frequent–occasional.
Vegetation: Open-forest and riparian scrub e.g. with *Tristaniopsis laurina, Kunzea ambigua.*
Substrate: Mainly sandy soil or loose sandstone, low nutrients.
Exposure: Sheltered; deep–mid shade.

Conservation

Conservation: Conservation status unknown.

Opercularia diphylla RUBIACEAE

Life history

Growth form: Small weak procumbent herb, with short rootstock.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: August–February.
Fruit/seed: Compound capsule 3–8 mm diam., November–May.
Dispersal, establishment & growth: Soil-stored seedbank (Fox 1988).
Fire response: Probably resprouts (Herbarium specimen).
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC **CC** SC **CT** NWS CWS; Qld.
Distribution Sydney area: Mainly Western Sydney.
Select locations: **CC**: Drews Creek, Maralya, Llandilo, Duck River, Liverpool, Macquarie Fields, Silverdale, Oakdale, Thirlmere Lakes, Appin, Mt Keira, Kowmung Valley. **CT**: Mittagong.

Habitat

Habitat:
Altitude: 0–700 m **Annual rainfall:** 700–1000 mm
Typical local abundance: Rare–occasional.
Vegetation: Woodland e.g. with *Eucalyptus tereticornis, E. crebra, E. fibrosa*; open-forest e.g. with *Eucalyptus mannifera.*
Substrate: Clay soils on Wianamatta Shale, Tertiary alluvium, quartzite, medium nutrients.
Exposure:

Conservation

Conservation: Conservation status unknown. Reported in Yengo NP.

Opercularia hispida RUBIACEAE

Hairy Stinkweed

Life history

Growth form: Prostrate to erect herb, with numerous stems arising from a central taproot.
Vegetative spread: No (McIntyre et al. 1995).
Longevity:
Primary juvenile period:
Flowers: September–February.
Fruit/seed: Compound capsule 4–10 mm diam., seeds wrinkled, September–May.
Dispersal, establishment & growth: No particular morphology for dispersal (McIntyre et al. 1995).
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: NC **CC** SC NT **CT** ST NWS CWS SWS; Qld, Vic.
Distribution Sydney area:
Select locations: **CC**: Culoul Range, Glen Davis, Wisemans Ferry, Brooklyn, Turramurra, Ingleburn, Douglas Park, Tuglow Caves. **CT**: Hartley Vale, Jenolan Caves, Hill Top, Bundanoon.

Habitat

Habitat: Among rocks, creekbeds, valleys.
Altitude: 0–1000 m **Annual rainfall:** 600–1200 mm
Typical local abundance: Frequent–occasional.
Vegetation: Moist eucalypt forest, woodland e.g. with *Eucalyptus dives, E. viminalis, E. rubida.*
Substrate: Sandy soils on sandstone, alluvium, quartzite, slate, medium nutrients.
Exposure:

Conservation

Conservation: Vulnerable in Western Sydney (James et al. 1999). Conservation status elsewhere unknown. Reported in Muogamarra Nature Reserve, Ku-ring-gai Chase NP.

Opercularia varia RUBIACEAE

Variable Stinkweed

Life history

Growth form: Spreading subshrub to 30 cm high, with numerous branches from one short main stem; leaves pungent-smelling.
Vegetative spread:
Longevity: 5–20 years (D. Keith pers. comm.).
Primary juvenile period: 2 years (Keith 1996).
Flowers: October.
Fruit/seed: Compound capsule 2–5 mm diam., September–January.
Dispersal, establishment & growth: Recruitment mainly after fire (D. Keith pers. comm.).
Fire response: Killed (Keith 1996). Some plants probably resprouted after high intensity fire (1/1994) at Lane Cove (P. Kubiak pers. comm.).
Interaction with other organisms: Often heavily cropped by rabbits (P. Kubiak pers. comm.).

Distribution

Status/origin: Native.
Botanical subregions: NC **CC** SC **CT** ST SWS; Vic., Tas., S.A.
Distribution Sydney area:
Select locations: **CC**: Dural, Hornsby, Narrabeen, Cumberland SF, Maquarie Fields, Maroubra Bay. **CT**: Mt Wilson, Armour Range, Hill Top, Robertson, Mittagong.

Habitat

Habitat:
Altitude: 0–1000 m **Annual rainfall:** 800–1600 mm
Typical local abundance: Occasional.
Vegetation: Open-forest e.g. with *Eucalyptus sieberi, Corymbia gummifera, Eucalyptus piperita, Angophora costata;* wet heath e.g. with *Baeckea linifolia, Leptospermum juniperinum.*
Substrate: Sandy soil on sandstone, low nutrients.
Exposure:

Conservation

Conservation: Conservation status unknown. Reported in Brisbane Water NP, Muogamarra Nature Reserve, Ku-ring-gai Chase NP, Garigal NP, Lane Cove NP, Sydney Harbour NP.

Pomax umbellata RUBIACEAE

Life history

Growth form: Small perennial sub-herb to 40 cm high.
Vegetative spread: No.
Longevity: short - medium.
Primary juvenile period: Less than 1 year (P. Kubiak pers. comm.).
Flowers: Reddish, September–December, peak September.
Fruit/seed: Compound capsule, dehiscent. Seeds 2–3 mm long, mean weight 1.14 mg (J. Howell pers. comm.), mature October–December.
Dispersal, establishment & growth: Diaspore: seed, ejected ballistically when ripe capsules touched (J. Howell pers. comm.). Soil-stored seedbank (Fox 1988). Coloniser.
Fire response: Killed by fire (Fox 1988).
Interaction with other organisms: Considered to be a potential producer of hydrocyanic acid (Hurst 1942).

Distribution

Status/origin: Native.
Botanical subregions: NC **CC** SC NT **CT** ST NWS CWS NWP SWP NFWP SFWP; Qld, Vic., N.T., S.A., W.A.
Distribution Sydney area: Widespread.
Select locations: **CC**: Toukley, Woy Woy, Wisemans Ferry, Hornsby, Lane Cove, Macquarie Fields, Yerranderie, Kowmung River. **CT**: Rylstone, Coricudgy, Katoomba, Jenolan Caves.

Habitat

Habitat: Ridges, cliff tops.
Altitude: 0–1000 m **Annual rainfall:** 700–1400 mm
Typical local abundance: Frequent.
Vegetation: Dry open-forest and woodland e.g. with *Eucalyptus sclerophylla, Angophora bakeri, Corymbia eximia, Angophora costata, Corymbia gummifera.*
Substrate: Sandy soil on sandstone, low nutrients, well-drained.
Exposure: Full sun.

Conservation

Conservation: Probably adequately conserved. Reported in Bouddi NP, Brisbane Water NP, Muogamarra Nature Reserve, Ku-ring-gai Chase NP, Garigal NP, Lane Cove NP, Sydney Harbour NP.

Psychotria loniceroides RUBIACEAE

Hairy Psychotria

Life history

Growth form: Shrub or small tree to 5 m high, with white or rusty hairs on young growth, leaves and inflorescence; sometimes with pouches (domatia) in leaf axils.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: White, February–April.
Fruit/seed: Whitish to yellowish egg-shaped fleshy fruit 6–8 mm long, fresh weight 100–200 mg (Westoby et al. 1990), ribbed and furrowed lengwise, May–July.
Dispersal, establishment & growth: Diaspore: fleshy fruit, vertebrate-adapted for dispersal (Westoby et al. 1990).
Fire response:
Interaction with other organisms: Larval food plant of Hawkmoth *Macroglossum hirundo* subsp. *errans* (Common 1990).

Distribution

Status/origin: Native.
Botanical subregions: NC **CC** SC NT **CT**; Qld.
Distribution Sydney area: Coast.
Select locations: **CC**: Wyong, Gosford, Newport, Pymble, Kurrajong Heights, Mountain Lagoon, Hurstville, Waterfall, Mt Kembla, Minnumurra Falls, Cambewarra Range. **CT**: Moss Vale.

Habitat

Habitat: Tall open-forest and rainforest (R. Payne pers. comm.).
Altitude: 0–600 m **Annual rainfall:** 900–1600 mm
Typical local abundance: Frequent.
Vegetation: Rainforest and moist eucalypt forest e.g. with *Eucalyptus saligna, Syncarpia glomulifera.*
Substrate: Clay soil on basalt, volcanics, Wianamatta Shale, Narrabeen Sandstones. Soil pH 4.5–5.5 (R. Payne pers. comm.).
Exposure:

Conservation

Conservation: Conservation status unknown. Reported in Bouddi NP, Wambina NR, Dalrymple Hay NR.

Richardia brasiliensis * RUBIACEAE

White Eye, Mexican Clover

Life history

Growth form: Prostrate to ascending herb, with hairy stems to 40 cm long, possibly rhizomatous.
Vegetative spread:
Longevity: Less than 1 year.
Primary juvenile period: Less than 1 year.
Flowers: White, tubular, in a head, January.
Fruit/seed: Dehiscent fruit of 3 segments, 2-3 mm long.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms: Food plant of butterfly larvae *Hypolimnas bolina nerina* (Common & Waterhouse 1981).

Distribution

Status/origin: Exotic, native to S America.
Botanical subregions: NC **CC**; Qld.
Distribution Sydney area: Lower Hawkesbury River area.
Select locations: **CC**: Woy Woy (1969), Ourimbah (1965), Cheltenham (1948), Wisemans Ferry (1958), MacDonald (1967), Central Colo (1987).

Habitat

Habitat: Roadsides, riverbanks.
Altitude: 0–200 m **Annual rainfall:** 900–1200 mm
Typical local abundance: Occasional.
Vegetation:
Substrate: Sandy soil on alluvium, medium nutrients.
Exposure:

Conservation

Conservation: Recently naturalised, 1940s–1950s, in Lower Hawkesbury River area, possibly spread in soil. Weed potential unknown.

Richardia humistrata * RUBIACEAE

Life history

Growth form: Prostrate perennial herb, with stems to 15 cm long.
Vegetative spread: Roots at nodes, often forms dense mats.
Longevity:
Primary juvenile period:
Flowers: White, tubular, in a head.
Fruit/seed: Dehiscent fruit of 4 segments, 2 mm long, March–May.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to S America.
Botanical subregions: NC CC.
Distribution Sydney area:
Select locations: CC: Wollombi (1986), Wyee (1993).

Habitat

Habitat: Disturbed sites.
Altitude: 0–100 m **Annual rainfall:** 1000–1100 mm
Typical local abundance: Frequent.
Vegetation:
Substrate: Sandy loam on sandstone.
Exposure:

Conservation

Conservation: Recently reported naturalised. Weed potential unknown, though its ability to spread vegetatively may allow it to be spread quickly.

Richardia stellaris * RUBIACEAE

Life history

Growth form: Prostrate perennial herb, with stems to 15 cm long.
Vegetative spread: No (McIntyre et al. 1995).
Longevity:
Primary juvenile period:
Flowers: White, in a head, October–April.
Fruit/seed: Dehiscent fruit of 4 segments, 2 mm long, October–February.
Dispersal, establishment & growth: No particular morphology for dispersal (McIntyre et al. 1995).
Fire response: Possibly resprouted after high intensity fire (1/1994) at Lane Cove, with some plants fruiting in 6 months (P. Kubiak pers. comm.)
Interaction with other organisms:

Distribution

Status/origin: Exotic, native to S America.
Botanical subregions: NC **CC** SC NT **CT** CWS; Qld.
Distribution Sydney area: Widespread at lower elevations.
Select locations: **CC**: Wisemans Ferry, Cheltenham, Mosman Bay (1844), Silverwater, Kogarah (1900), Ingleburn (1900), Mt Annan, The Oaks, Shellharbour, Lower Portland, Wisemans Ferry (1908), Warrimoo.

Habitat

Habitat: Roadsides.
Altitude: 0–700 m **Annual rainfall:** 800–1400 mm
Typical local abundance: Frequent.
Vegetation: Grassy areas, remnant woodland e.g. with *Bursaria spinosa.*
Substrate: Sandy soil near beaches, clay soil on shale, volcanics.
Exposure:

Conservation

Conservation: Probably naturalised since late 19th century, minor weed of grassy areas.

Sherardia arvensis * RUBIACEAE

Field Madder

Life history

Growth form: Ascending to procumbent herb, with weak stems to 30 cm long.
Vegetative spread: No.
Longevity: Less than one year.
Primary juvenile period: Less than one year.
Flowers: Pink to lilac, September–December.
Fruit/seed: Dry 2-lobed fruit 2–5 mm long.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native to Europe and W Asia.
Botanical subregions: **CC** SC NT **CT** ST NWS CWS SWS; Vic., Tas., N.T., S.A.
Distribution Sydney area: Mainly Illawarra and Southern Highlands.
Select locations: **CC**: Westmead, Prospect (1912), Ingleburn, Casula, St Marys, Camden, Kiama (1899), Kangaroo Valley, Berry. **CT**: Abercrombie Caves, Bowral.

Habitat

Habitat: Grassland, lawns, creekbanks.
Altitude: 0–700 m **Annual rainfall:** 800–1400 mm
Typical local abundance: Occasional.
Vegetation: Grassland.
Substrate: Clay soils on shale, alluvium, limestone, medium nutrients.
Exposure: Full sun.

Conservation

Conservation: Weed of gardens and disturbed areas.

Synaptantha tillaeacea RUBIACEAE

Life history

Growth form: Prostrate, succulent herb, with stems to 15 cm long, leaves opposite.
Vegetative spread:
Longevity:
Primary juvenile period:
Flowers: Whitish, July–October.
Fruit/seed: Capsule 1–2 mm wide, with 8–16 seeds.
Dispersal, establishment & growth:
Fire response:
Interaction with other organisms:

Distribution

Status/origin: Native.
Botanical subregions: **CT** NWS CWS NWP NFWP SFWP; Qld, N.T., S.A., W.A.
Distribution Sydney area: Blue Mountains.
Select locations: **CT**: Mt Victoria (1882) only record.

Habitat

Habitat:
Altitude: **Annual rainfall:**
Typical local abundance:
Vegetation:
Substrate:
Exposure:

Conservation

Conservation: Mainly found in northwest New South Wales, with only one record for Central Tablelands at Mount Victoria (1882). Possibly now extinct in the Sydney area.

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Scientific names are in bold type and synonyms are in italics. Family names are in upper case. Common names are in roman type. Exotic species are indicated by an asterisk following the botanical name.

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Corrigendum – Cunninghamia 6(3) p. 529

Toivo Zoete. Vegetation survey of the Barrington Tops and Mount Royal National Parks for use in fire management

Page 524: The text on this page (23 lines) is a continuation of the section on **Ordination** on p. 529. The section should read as follows:

Ordination

The DCA ordination of plots resulted in eigen values of 0.7979, 0.6558, 0.4155, and 0.3743 for the first four dimensions respectively, with corresponding gradient lengths of 8.918, 6.181, 4.763, and 4.719. This indicates that there is at least one complete species turnover along each of these axes, with two turnovers in the first dimension. Thus, the species composition on the one end of the axis is completely different from that on the other end of the axis, with two such cycles in the first dimension (i.e. the first axis shows most of the variation).

Principal axis correlations for environmental variables are also listed in Table 6. Figs 4 and 5 show the vectors (standard length = 1) for variables with correlations over 0.5 and $p < 0.01$ in relation to the distribution of the plots in the first three dimensions of the species space.

Fig. 4 shows that the major floristic gradient (dimension 1) in the vegetation is from sub-alpine swamp (Community 12) and montane *Eucalyptus* spp. dominated vegetation types (Community 9 to 11) to rainforest (Community 7) and wet sclerophyll forest (Community 8). Another important gradient (dimension 2) is from the *Nothofagus moorei* dominated forests to the drier *Eucalyptus* spp. forests. Both floristic gradients appear to be related to changes in altitude, rainfall, temperature, and latitude, while time since last fire is particularly correlated with the second dimension.

The third floristic gradient is less clear but highlights the distinctiveness of some riparian vegetation types (Communities 5 and 11) at one extreme (Fig. 5). This pattern appears to be correlated to geology, soil fertility, and longitude.

Correlations with fire response mechanisms were weak but mostly significant (Table 8). The only mechanism which was insignificant was mechanism 11 (obligate resprouters). Only three mechanism had correlations over 0.5 ('resprouters', and mechanisms 4 and 5).

Pages 567–577: Running head should read 'Zoete, Barrington Tops and Mount Royal National Park'

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Issue 1

Vegetation of the South East Forests Region, Eden New South Wales (Northern sheet)

David Keith & Michael Bedward

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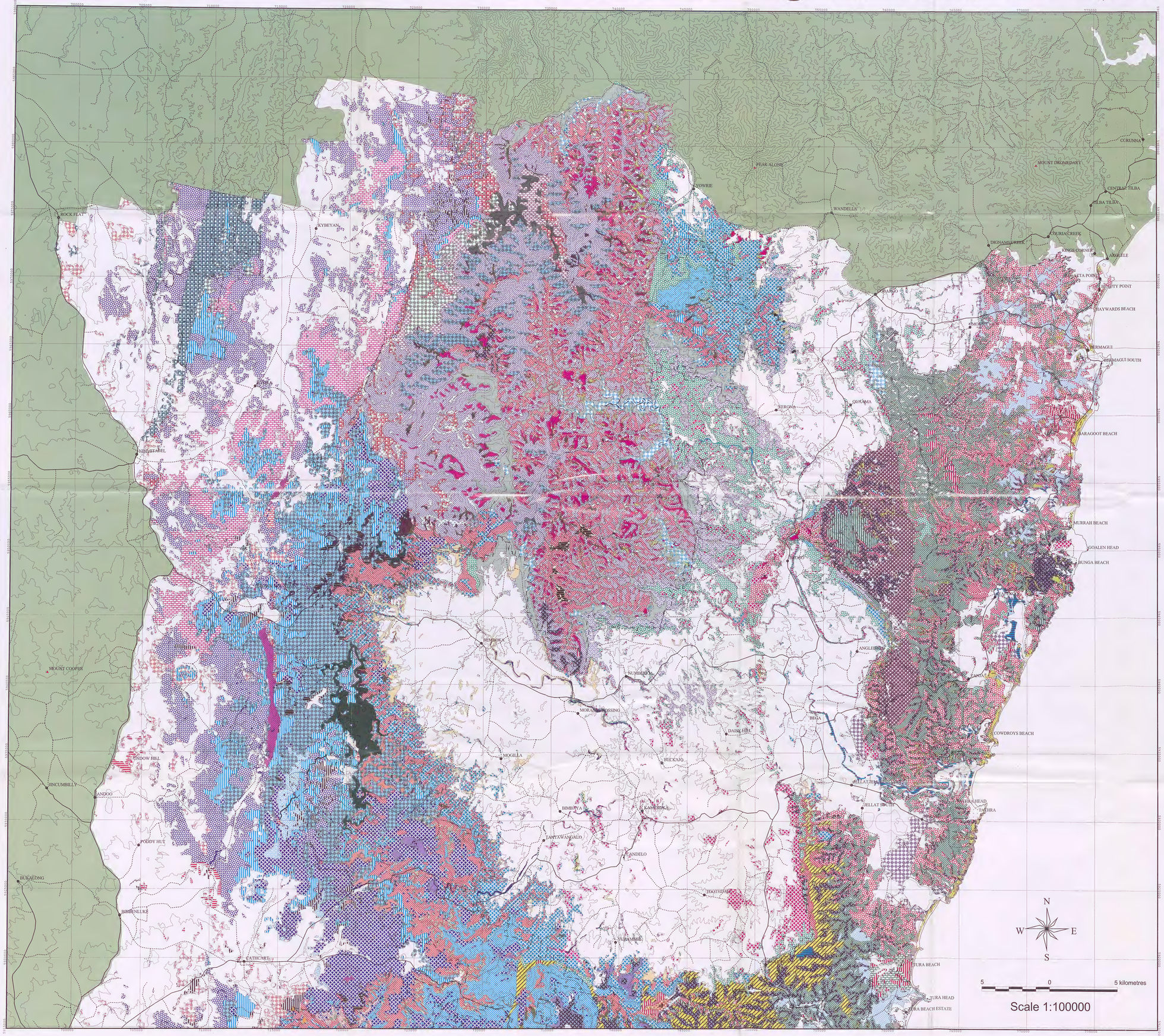
Vegetation of the South East Forests Region, Eden, NSW (Northern sheet)



1: Dry Rainforest
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3: Rocky Tops Dry Scrub Forest
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5: Bunga Head Rainforest
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Urban area
Waterbody
Outside Study Area
Cleared Land
Mountain
Town
Sealed Roads
Trails
Reserve

Contour Interval 100m
Grid Interval 5km
Australian Map Grid Zone 55

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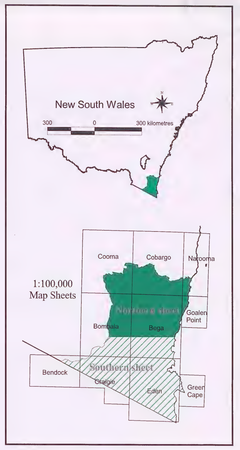
Lowland Gully Shrub Forest (Map Unit 37) at Saltwater Creek, near Eden



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David Keith & Michael Bedward

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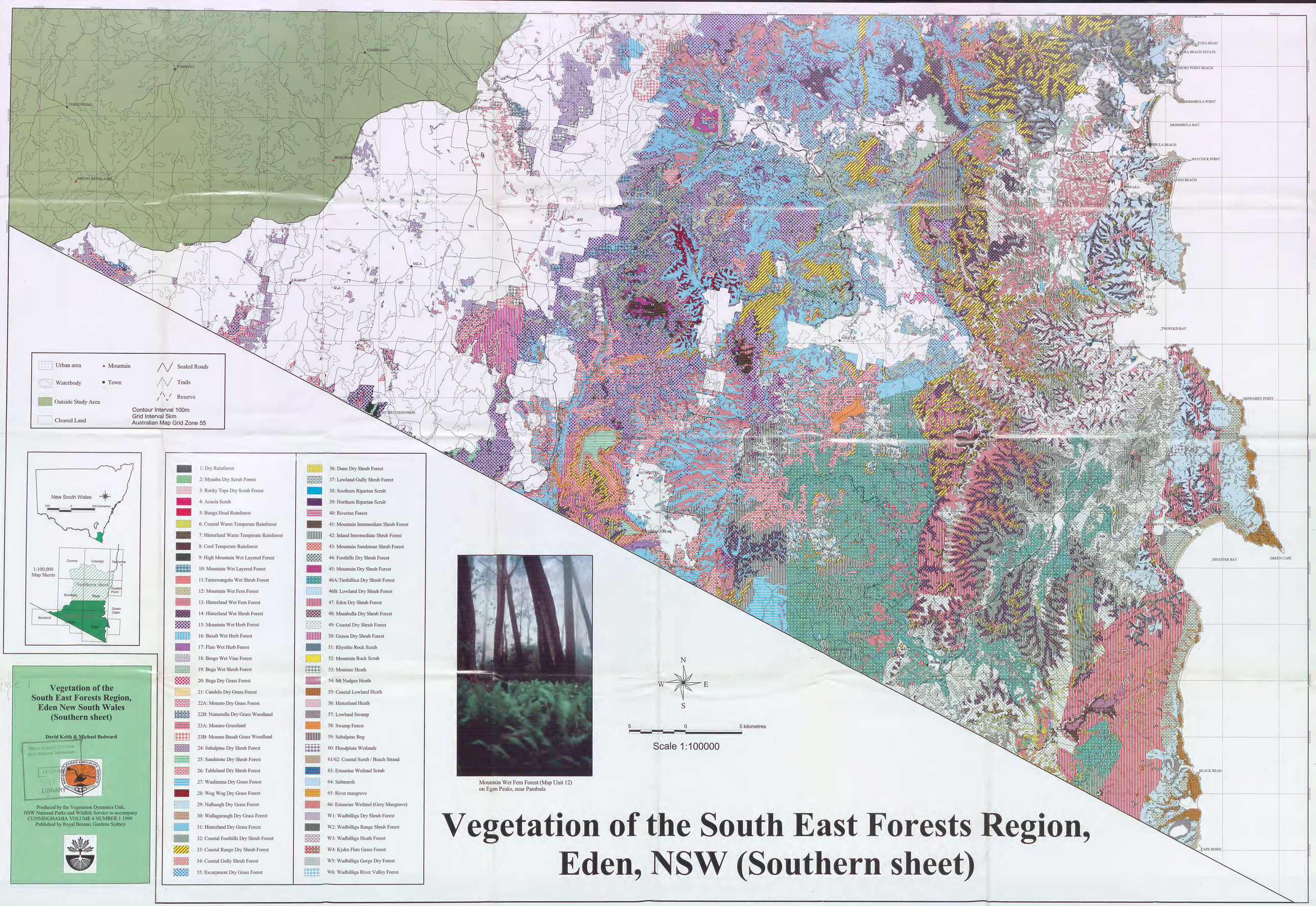

Mountain Wet Fern Forest (Map Unit 12) on Egan Peaks, near Pambula

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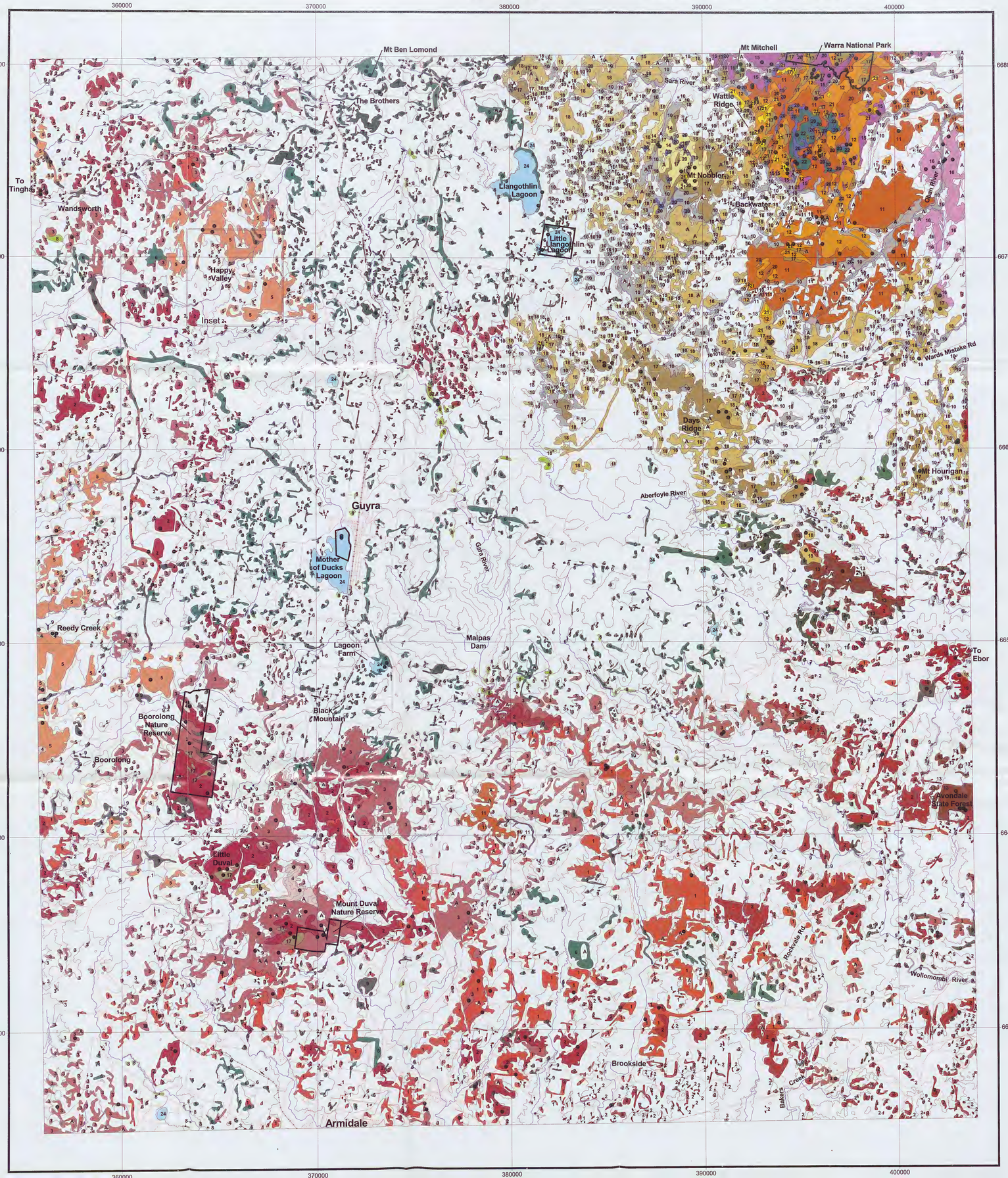


Plant Communities

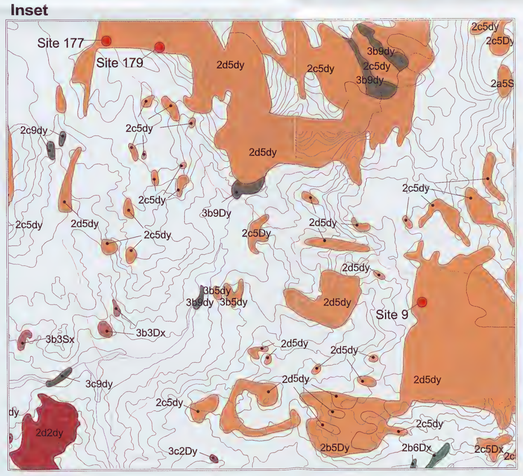
(Shown in the same order as that in the numerical analysis)

1. *Eucalyptus blakelyi* - *E. melliodora* Open Forest mainly on sediments
2. *Eucalyptus caliginosa* Open Forest on various substrates, mainly sediments
19. *Eucalyptus acaciiformis* - *E. caliginosa* - *E. radiata* subsp. *sejuncta* Open Forest on sediments
3. *Eucalyptus laevopinea* Open Forest on various substrates
4. *Eucalyptus banksii* - *E. laevopinia* Open Forest mainly on acid volcanics
5. *Eucalyptus youmanii* - *E. andrewsii* - *E. subtilior* ± *E. nicholii* Open Forest on acid volcanics
6. *Eucalyptus viminalis* - *E. dalrympleana* subsp. *heptantha* - *E. pauciflora* Tall Open Forest - grassy understorey on basalt
7. *Eucalyptus stellulata* - *E. pauciflora* Low Open Forest or Low Open Woodland - grassy understorey, mainly basalt
9. *Eucalyptus nova-anglica* Woodland mainly on sediments and acid volcanics
10. *Eucalyptus nova-anglica* - *E. pauciflora* Open Forest on granite and leucogranite
8. *Eucalyptus nova-anglica* Woodland on basalt
11. *Eucalyptus caliginosa* - *E. dalrympleana* subsp. *heptantha* Open Forest on leucogranite
12. *Eucalyptus campanulata* Open Forest on leucogranite
13. *Eucalyptus laevopinea* - *E. nobilis* Open Forest on sediments
14. *Eucalyptus radiata* subsp. *sejuncta* - *E. nobilis* - *Hovea sp. A* Open Forest on granite
15. *Eucalyptus nobilis* - *E. caliginosa* Open Forest on leucogranite
16. *Eucalyptus caliginosa* - *E. nobilis* - *E. blakelyi* Open Forest, Oban River on granite
17. *Eucalyptus obliqua* - *E. nobilis* Tall Open Forest on protected sites on various substrates
18. *Eucalyptus radiata* subsp. *sejuncta* - *E. acaciiformis* Open Forest on granite
20. Heath Swamps on leucogranite and granite
21. Mallee and Heath on rocky outcrops on leucogranite
22. *Eucalyptus radiata* subsp. *sejuncta* - *E. caliginosa* Open Forest with Dense Shrubland on leucogranite
24. Basalt Plateau Lagoons

A. Agricultural land cleared of woody vegetation or thinned >75% of pre-1750 density

(Note: 23. New England Riparian Shrubland not shown due to its narrow width lining creeks on various substrates)

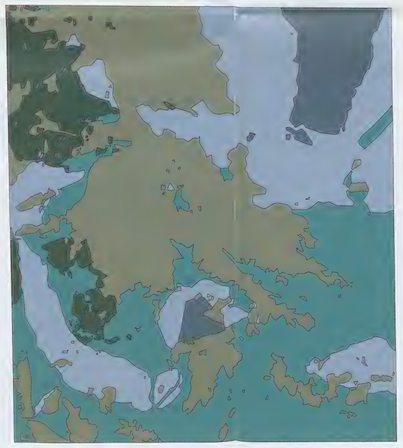
Inset



Example of detail contained within 1:25 000 source maps. The alphanumeric vegetation codes describe (in order) the height category of the overstorey, crown cover density, plant community, disturbance estimate and understorey type. This is the level of detail available in ArcView 3.1 format from the Royal Botanic Gardens Sydney.

Simplified Geology map

(derived from Guyra 1:100 000 Geological map, Dept Mineral Resources)



Basalt
Granite
Leucogranite
Acid Volcanics
Sediments

Natural Vegetation of the GUYRA (New South Wales) 1:100 000 Map Sheet

John S. Benson
Elizabeth M. Ashby

Descriptions of the plant communities are given in *Cunninghamia* 6 (3) 2000

Compiled and prepared at the National Herbarium of New South Wales

ROYAL BOTANIC GARDENS SYDNEY

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Understanding the ecology of our native plants

Key to adjoining 1:100 000 maps

Inverell 9138	Glen Innes 9238	Newton Boyd 9338
Bundarra 9137	***Guyra* 9237**	Ebor 9337
Bendemeer 9136	Armidale 9236	Carrai 9336

N

km 0 5 10

Key to other features

- Roads
- Railway
- Main Rivers & Creeks
- Contours, 50 m
- National Parks & Nature Reserves
- Sample sites

Vegetation boundaries based on interpretation of 1:25000 1989 colour aerial photography (NSW 3680,3682 & 3685). More recent clearing was detected (and mapped) during field traverses from 1992 to 1997.

Base Mapping (1:25 000, Australian Geodetic Datum 1966) supplied by:
THE LAND INFORMATION CENTRE
PANORAMA AVENUE BATHURST 2795
www.lic.gov.au

VEGETATION OF BOOTI BOOTI NATIONAL PARK AND YAHOO NATURE RESERVE

Lower North Coast of New South Wales

1:25 000 Map Sheet

Produced by S.J.Griffith, R.Wilson and K.Maryott-Brown
for the New South Wales National Parks and Wildlife Service
to accompany
CUNNINGHAMIA VOLUME 6 NUMBER 3
2000.
Royal Botanic Gardens Sydney

Comments:

#1 The structural classification follows Walker and Hopkins (1984). The communities are named after dominant indicator species of the tallest (dominant) stratum, and most could be considered associations using the definition of Beadle (1981): 'a community in which the dominant stratum exhibits uniform floristic composition, the community usually exhibiting uniform structure (also)'. Five-digit numeric codes are used for mapping purposes to identify individual plant communities, and also other map units such as cleared land. The first four digits of each code identify the formation, subformation and community. A fifth digit is used on the vegetation map to signify the crown cover range of the tallest stratum: 1 = mid-dense to dense (e.g. open to closed forest); 2 = very sparse to sparse (e.g. open woodland to woodland); 0 = crown cover variable, or else not determined. The '0' code is only used for 'complex' map units and 'miscellaneous' map units. In some instances it was not possible to map communities discretely at a scale of 1: 25,000. This situation arose where communities were too fragmented and intermixed (e.g. along foredunes and sea cliffs), or else formed seemingly broad ecotones or 'mixed stands' (after Beadle 1981). In some situations where communities closely intermix, micro-relief varies over small distances. For simplicity of mapping, commonly encountered mixed stands which are perceived to comprise two communities have been assigned a distinct map code (i.e. 40981/2 and 40991/2). Less common mixed stands are simply mapped using a dual code (e.g. 64021/65031). Fragmented and intermixed vegetation which comprises more than two communities is often found on foredunes, in saltmarshes, and along seacliffs. In such situations appropriately annotated complex map units are employed.

#2 This community has been named after the equivalent suballiance circumscribed by Floyd (1990).

#3 Unlike community 35561/2 (which is found on deep sands, and commonly referred to as 'Sandhill Blackbutt'), this community occurs on bedrock sites.

#4 Intermediate dry heathland supports a mixture of typical 'wet heathland' (60021) and 'dry heathland' (58041) species, and is a feature of very deflated sandplains on the NSW North Coast which display little or no slope and aspect. Where the topography becomes more pronounced, intermediate dry heathland is replaced by dry heathland upslope on dunes and beach ridges, and by wet heathland downslope in swales.

#5 Given a favourable fire regime, recruitment of the obligate seeder *Banksia ericifolia* var. *macrantha* may occur in wet heathland. *Banksia ericifolia* var. *macrantha* can in time overtop other species to form dense stands of shrubland.

#6 This community has not been mapped separately but included in 90300.

#7 This community has not been mapped separately but included in 90100.

Reference notes (used to identify features which are too small to map, but nonetheless of interest):

- A A small stand of 10031 is present.
- B *Melaleuca quinquenervia* is present as an emergent in excess of 5% of total crown cover for the tallest stratum.
- C *Angophora costata* is locally absent.
- D *Allocasuarina simulans* is locally absent.
- E *Corymbia maculata* is locally abundant in places.
- F *Eucalyptus grandis* and *Corymbia intermedia* are locally abundant in places.
- G A small stand of *Angophora costata* is present, and this is probably a remnant of a larger stand which originally extended onto what is now a picnic area.
- H This is a very degraded stand of *Angophora costata* with associated *Banksia serrata* which appears to have suffered from frequent fire and exposure. This stand may have originally been 35561.
- I Small stands of *Eucalyptus tereticornis* - *E. microcorys* forest fringe the lake foreshore.
- J Localised stands of *Eucalyptus pilularis* wet sclerophyll forest (30061) are present.
- K Rainforest species are locally common in association with *Casuarina glauca*.

Aerial photography:

Bulahdelah 1: 25,000 Colour (NSW 4037). Runs 6,7,8,9. Flown 14.9.1991. NSW Department of Land & Water Conservation.

References:

Beadle, N.C.W. (1981) *The vegetation of Australia.* (Cambridge University Press: Cambridge).
Floyd, A.G. (1990) *Australian rainforests in New South Wales.* Volumes 1-2 (Surrey Beatty and Sons - NSW National Parks & Wildlife Service: Chipping Norton).
Walker, J. & Hopkins, M.S. (1984) Vegetation. In R.C. McDonald, R.F. Isbell, J.G. Speight, J. Walker & M.S. Hopkins (eds) *Australian soil and land survey field handbook.* pp. 44-67. (Inkata Press: Melbourne).

Air photo interpretation and mapping by R. Wilson. Botany by S.J. Griffith and K. Maryott-Brown.

MAP CODE	COMMUNITY #1
	FORMATION: FOREST AND WOODLAND
	Subtropical rainforest
00031	*Livistona australis* simple, tall to very tall closed fan palm forest
	Littoral rainforest
05021	*Cupaniopsis anacardioides* simple, notophyll-microphyll, low to tall closed forest #2
05051	*Drypetes deplanchei* - *Sarcomelicope simplicifolia* subsp. *simplicifolia* - *Cassine australis* var. *australis* - *Podocarpus elatus* simple, notophyll-microphyll, low to very tall closed forest #2
	Dry rainforest
10031	*Ficus* spp. - *Streblus brunonianus* - *Dendrocnide* spp. - *Cassine australis* var. *australis* simple, notophyll, mid-high to tall closed forest #2
10041	*Choricarpia leptopetala* simple, notophyll, low to tall closed forest #2
	Mangrove woodland
25022	*Avicennia marina* subsp. *australasica* low to mid-high open woodland and woodland
	Wet sclerophyll forest
30021	*Lophostemon confertus* mid-high to very tall, open to closed forest
30041	*Eucalyptus grandis* very tall open to closed forest
30061	*Eucalyptus pilularis* very tall open to closed forest
30071	*Eucalyptus microcorys* very tall open to closed forest
30111	*Eucalyptus tereticornis* mid-high to very tall, open to closed forest
30121	*Eucalyptus fergusonii* subsp. *fergusonii* tall to very tall, open to closed forest
30131	*Corymbia maculata* - *Eucalyptus fergusonii* subsp. *fergusonii* - *E. acmenoides* very tall open to closed forest
	Dry sclerophyll forest and woodland
35041	*Eucalyptus pilularis* tall to very tall, open to closed forest #3
35081	*Eucalyptus microcorys* mid-high to very tall, open to closed forest
35121 35122	*Eucalyptus tereticornis* mid-high to tall, open woodland to closed forest
35131	*Allocasuarina littoralis* low open to closed forest
35221 35222	*Angophora costata* mid-high to very tall, open woodland to closed forest
35561 35562	*Eucalyptus pilularis* – *Angophora costata* tall to very tall, woodland to closed forest
35591	*Corymbia maculata* – *Eucalyptus fergusonii* subsp. *fergusonii* – *E. acmenoides* mid-high to tall, open to closed forest
35601	*Eucalyptus tereticornis* – *E. microcorys* mid-high to very tall, open to closed forest
35611 #6	*Angophora floribunda* low to mid-high, open to closed forest
35621	*Corymbia maculata* tall to very tall, open to closed forest
	Swamp sclerophyll forest and woodland
40031 40032	*Melaleuca quinquenervia* mid-high to very tall, open woodland to closed forest
40051 40052	*Casuarina glauca* mid-high to very tall, open woodland to closed forest
40981 40982	*Eucalyptus robusta* – *Melaleuca quinquenervia* mid-high to very tall, open woodland to closed forest
40991 40992	*Melaleuca quinquenervia* – *Casuarina glauca* mid-high to very tall, open woodland to closed forest
	FORMATION: MALLEE WOODLAND
	Dry sclerophyll mallee woodland
50022	*Eucalyptus pilularis* very tall to extremely tall, mallee woodland and open mallee woodland
	Swamp sclerophyll mallee woodland
51022	*Eucalyptus robusta* very tall to extremely tall, mallee woodland and open mallee woodland
	FORMATION: SHRUBLAND (SCRUB)
	Rain-shrubland
52031	*Choricarpia leptopetala* simple, notophyll, tall to very tall closed shrubland #2
	Dry sclerophyll shrubland
54021	*Banksia aemula* tall to very tall, open to closed shrubland
54041	*Melaleuca armillaris* very tall closed shrubland
54101	*Leptospermum laevigatum* tall to very tall closed shrubland
54111 #7	**Chrysanthemoides monilifera* subsp. *rotundata* - *Acacia sophorae* mid-high to tall closed shrubland
	Swamp sclerophyll shrubland
55062	*Melaleuca quinquenervia* tall to very tall, sparse to open shrubland
	FORMATION: HEATHLAND
	Dry heathland
58041	*Banksia aemula* - *Allocasuarina simulans* mid-high to tall closed heathland
58991	Intermediate dry heathland (mid-high to tall closed heathland) #4
	Graminoid clay heathland
59051	*Banksia spinulosa* var. *collina* - *Allocasuarina littoralis* - *Hakea teretifolia* - *Ptilothrix deusta* - *Themeda australis* low to mid-high closed heathland
	Wet heathland
60021	*Banksia oblongifolia* - *Leptospermum liversidgei* - *Sporadanthus interruptus* - *Sprengelia sprengelioides* - *Xanthorrhoea fulva* mid-high to tall closed heathland #5
	FORMATION: CHENOPOD SHRUBLAND
61021	*Sarcocornia quinqueflora* subsp. *quinqueflora* - *Sporobolus virginicus* dwarf to low, open to closed chenopod shrubland/tussock grassland
	FORMATION: TUSSOCK GRASSLAND
62021 #7 62022 #7	*Spinifex sericeus* low to mid-high, sparse to closed tussock grassland
	FORMATION: SOD GRASSLAND
63021 #6	*Themeda australis* low to tall closed sod grassland
	FORMATION: SEDGELAND
64021	*Baumea juncea* mid-high to tall closed sedgeland
64031	*Leptocarpus tenax* - *Baloskion pallens* - *Schoenus brevifolius* tall to very tall closed sedgeland
	FORMATION: RUSHLAND
65021	*Juncus kraussii* subsp. *australiensis* tall to very tall closed rushland
65031	*Phragmites australis* very tall closed rushland
	VEGETATION COMPLEXES
90100	Foredune Complex: the main constituent communities are 54101, 54111 and 62021/2, although limited areas of 05021 and 40031 are also likely. Other species may dominate over small areas (e.g. *Banksia integrifolia* subsp. *integrifolia*, *Carex pumila*, *Lomandra longifolia*, *Scaevola calendulacea*, *Zoysia macrantha*). **Chrysanthemoides monilifera* subsp. *rotundata* is prevalent, and **Casuarina equisetifolia* subsp. *incana* has been planted at some locations. Much of the complex is regeneration following sand mining.
90200	Saltmarsh Complex: the main constituent communities are 61021, 64021 and 65021, with small areas of 25022, 65031 and unvegetated mudflat also likely. Other species may dominate over minor localised areas (e.g. *Paspalum vaginatum*, *Schoenoplectus litoralis*).
90300	Headland Complex: the main constituent communities are 35131, 35611, 40051, 54041 and 63021. Limited occurrences of 00031, 05021, 05051, 10041, 40031, 52031 and 54101 are also likely. On very exposed aspects, forest communities may grade into shrublands. Other species can dominate over small areas (e.g. *Banksia integrifolia* subsp. *integrifolia*, *Westringia fruticosa*). **Chrysanthemoides monilifera* subsp. *rotundata* is prevalent, and exotic grasses (e.g. **Pennisetum clandestinum*) occur as localised infestations.
	MISCELLANEOUS MAP UNITS
91020	Beach sand, mobile sand (occasionally sandy tidal flats)
91030	Rock
91040	Open water (dam)
92020	Partially cleared
92030	Cleared
92040	Disturbance associated with past mining (includes quarries)
92060	Picnic or camping area
92070	Disturbance associated with roads
92080	Disturbance associated with transmission line
92090	Urban or residential development and associated infrastructure (includes housing, public works etc.)

Community 52031: *Choricarpia leptopetala* rain-shrubland, northern end of the Cape Hawke hill complex.

Community 64021: *Baumea juncea* sedgeland near Green Point, last burnt in late January 1997. Also note crown fire damage to *Melaleuca quinquenervia* (background).

Community 35221: *Angophora costata* dry sclerophyll forest on a sand mantle over bedrock, southern end of the Cape Hawke hill complex.

Community 05051: *Drypetes deplanchei* - *Sarcomelicope simplicifolia* subsp. *simplicifolia* - *Cassine australis* var. *australis* - *Podocarpus elatus* littoral rainforest, southern end of the Cape Hawke hill complex.

Community 35591: *Corymbia maculata* – *Eucalyptus fergusonii* subsp. *fergusonii* – *E. acmenoides* dry sclerophyll forest, southern end of the Cape Hawke hill complex.

Community 60021: *Banksia oblongifolia* - *Leptospermum liversidgei* - *Sporadanthus interruptus* - *Sprengelia sprengelioides* - *Xanthorrhoea fulva* wet heathland, with *X. fulva* prominent following a severe fire in late January 1997.

Community 58041: *Banksia aemula* - *Allocasuarina simulans* dry heathland, recovering from a severe fire in late January 1997.

Community 54111: **Chrysanthemoides monilifera* subsp. *rotundata* - *Acacia sophorae* dry sclerophyll shrubland, north of the Booti Hill hill complex (background).

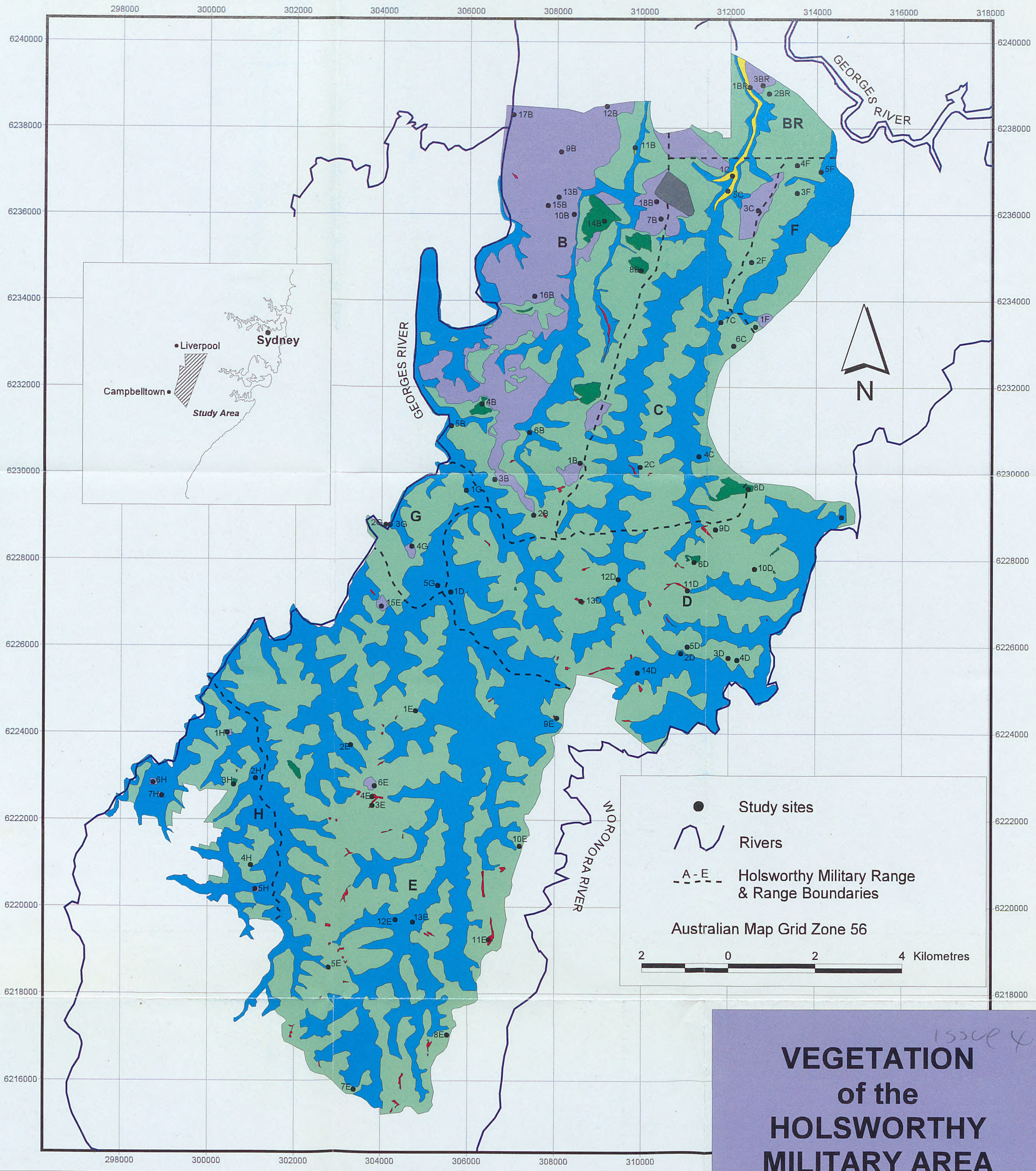
Community 35121: *Eucalyptus tereticornis* dry sclerophyll forest, northern end of the Booti Hill hill complex.

Community 63021: *Themeda australis* sod grassland with scattered emergent *Banksia integrifolia* subsp. *integrifolia* and *Westringia fruticosa*, on an exposed seaward slope of the Booti Hill hill complex.

Community 40031: *Melaleuca quinquenervia* swamp sclerophyll forest, last burnt in late January 1997.

Community 35041: *Eucalyptus pilularis* dry sclerophyll forest on bedrock, southern end of the Booti Hill hill complex.

Community 00031: *Livistona australis* subtropical rainforest (fan palm forest) at Shelly Beach, last burnt in the 1994/95 fire season.



	Vegetation		Main Species	Habitat
	Melaleuca Thicket		*Melaleuca linariifolia Gahnia sieberiana, Isolepis cernua.*	Waterlogged creek beds on deep alluvium.
	Cumberland Plain Communities	Plateau Forest on Shale	*Eucalyptus fibrosa, Bursaria spinosa, Themeda australis.*	Flat plateau tops on tertiary alluvium or shale.
		Shale/Sandstone Transition Forest	*Eucalyptus punctata, Banksia spinulosa, Entolasia stricta.*	Flat plateau tops on shale or sandstone.
	Gully Forest		*Angophora costata, Eucalyptus pilularis, Ceratopetalum gummiferum, Entolasia stricta.*	Well drained soils on slopes of sandstone gullies.
	Riparian Scrub		*Tristaniopsis laurina, Lomatia myricoides, Schoenus melenostachys.*	Along creek beds with alluvium on sandstone.
	Sedgeland		*Banksia oblongifolia, Leptocarpus tenax, Schoenus brevifolius, Baeckea imbricata.*	Damp sandy loams on sandstone above drainage lines.
	Woodland/Heath complex Heath (structural subunit of Woodland/Heath)		*Eucalyptus haemastoma/racemosa, Angophora hispida, Cyathochaeta diandra.*	Ridge tops with well drained to damp shallow sandy loams on sandstone. Heath subunit with laterite on sandstone.
	Sandstone Woodland		*Corymbia gummifera, Eucalyptus oblonga, Leptospermum trinervium, Lomandra glauca.*	Dry sandstone ridges with well drained shallow sandy loam on sandstone.
	Cleared			

VEGETATION of the HOLSWORTHY MILITARY AREA

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